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TECHNICAL DOCUMENT 269

HF ANTENNA SYSTEM DESIGN FOR PATROL HYDROFOIL (MISSILE) (PHM)

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Radio Technology Division

20 August 1973

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NAVAL ELECTRONICS LABORATORY CENTER
San Diego, California 92152

INTRODUCTION

The Patrol Hydrofoil, Missile (PHM), is a high-speed patrol craft planned for use by NATO forces. Two prototype vessels are being designed and built under Navy contract by Boeing Aerospace Company. Small size of the PHM – length 40 meters – coupled with the requirement for a rather extensive communications capability for this size ship in addition to weapon requirements poses difficult antenna placement problems. This is especially true of hf, for which antenna spacing in terms of wavelength must of necessity be small.

NELC was tasked by NAVSHIPS, PMS-303.6, to provide an hf antenna system design study for PHM in conjunction with the overall communications design effort being pursued by Boeing.

Requirements for the hf (2–30 MHz) subsystem on PHM specify two 1-kW transceive circuits capable of simultaneous operation and providing gapless 556-kilometer coverage. Limited topside space available for antennas precludes the use of broadband antennas with multicouplers. Thus, narrow-band antennas such as whips or dipoles used with antenna couplers, or some other type of tuned antennas are necessary in order to cover the wide hf range.

Simultaneous transmission with closely spaced antennas having automatically tuned base antenna couplers is a problem on existing Navy ships. The AN/URA-38, the Navy's only automatic antenna coupler, has serious interference problems when operated physically close to a second radiating source.

A report[1] has been written documenting the AN/URA-38 problem. A second automatic antenna coupler being considered for PHM application is the 490T-3 type (SIMOP version) manufactured by Collins Radio Company primarily for aircraft. This coupler had been tested successfully by Naval Air Development Center (NADC) with two hf antennas transmitting simultaneously on the P3A/B aircraft. Measurements performed at NELC[2] – using the 490T-3 with two whip antennas over a ground plane and at whip spacings which would be practical on PHM – showed that mistuning or no tuning of the 490T would also occur, depending on frequency spacing and power level used.

The objective of the NELC study was to provide two hf antennas (1) with the maximum isolation possible between them, (2) with reasonable antenna system efficiency, and (3) so arranged that they would meet the near-field-level requirement for the PHM weapons.

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[1]NELC Technical Document TD 170, "Mistuning of AN/URA-38: and AN/URA-38 Antenna Coupler Groups in the Presence of Interfering Signals," by J. L. Lievens, 20 March 1972

[2]NELC ltr ser 2100-108 to NAVSHIPS, PMS-391 of 19 May 1973, subject, Tests conducted on the Collins 490T-3 SIMOP antenna coupler in support of the PHM program

MEASUREMENT PROGRAM

Work on the hf antenna subsystem design at the NELC model range was done on a 1/50-scale brass model of PHM built from drawings supplied by Boeing. The antenna arrangement chosen was (1) a whip antenna on the port side just aft of the pilot house at the 01 level and (2) a three-wire bent-fan antenna strung from the mast aft and fed at deck level (fig. 1). Boeing had already explored isolation between various antenna locations with two 10.67-meter whips. The antennas are to be matched. A base-mounted antenna coupler, the 490T-type SIMOP coupler, is considered a most likely candidate. Tuned antennas such as the helical monopole were rejected, as no automatically tuned and/or production model is available. It is felt that on PHM, automatic tuning is highly desirable because of limited manning and automatically tuned transceivers.

Data on the PHM model were taken for whip lengths of 5.33 and 10.67 meters, as both were considered candidate antennas. Overall length of the fan is about 10.7 meters. Spacing between fan and whip at the nearest point is 9.75 meters, which is the maximum possible without getting overly close to the Harpoon missile launcher aft and the OTO Melara gun forward of the pilot house. Impedance measurements were made for several variations in fan size, including a configuration in which the feed was terminated about 2 meters above deck at the mast support. The form shown in figure 1 was found to be the best compromise. A second whip, 5.33 meters long, mounted starboard opposite the first whip, is designated for the backup receive circuit.

Data were taken on the hf antenna configuration of figure 1 for both hullborne and foilborne ship attitudes. Impedance, pattern, and isolation measurements or data were obtained for both ship attitudes. Near-field calculations were used to determine the expected peak fields in volts per meter for the antenna-to-weapon spacings chosen.

IMPEDANCE DATA

Impedance data for the three antennas measured are presented in figures 2–4. In general, the impedance curves were similar in shape for hullborne and foilborne altitudes. Data were taken with the General Radio type 1602B admittance meter and a Hewlett Packard network analyzer and S-parameter test set. The test setup is shown in figure 5. At frequencies above 20 MHz full scale it was felt that greater accuracy could be obtained with the admittance meter. Neither method would give sufficient resolution to make an accurate determination of antenna resistance at frequencies below about 5 MHz.

In order to ensure that the resistance value of the fan antenna was great enough so that excessive antenna coupler losses and possible coupler damage would not occur, a full-scale mock-up was constructed. The PHM mast was simulated by a grounded 10.67-meter AS-2537/SR whip with a metallic yardarm mounted on and electrically bonded to the whip top. From the cross arm the fan made of stranded copper wire 2 mm in diameter and having the dimensions shown in figure 1 was rigged. The feedpoint terminated at a small porcelain insulator 15 cm above the ground plane.

Impedance values taken with a General Radio 1606A bridge are listed in table 1.

TABLE 1. IMPEDANCE VALUES.

Freq, MHz	R, ohms	F, ohms
2	1.2	-j440
3	2.0	-j257
4	2.1	-j148
5.1	23.5	-j56

There is considerable variation in the reactance values of figure 2 (appendix) and table 1 which may be due in part to some error in measuring very-low-resistance, high-reactance loads on the model. However, one would expect a somewhat higher reactance value, because the full-scale fan, lacking the elevated ship platform, goes through first resonance at a higher frequency—appears electrically shorter—than the fan on the model. Also, because of this pedestal effect the resistance may be somewhat greater when the antenna is mounted aboard PHM.

PATTERN DATA

Pattern data (vertical polarization) were taken on the NELC model range for representative frequencies only, both in azimuth and elevation. In addition, some azimuthal patterns were taken on the fan above 10 MHz for horizontal polarization. All patterns taken were referenced to a vertical quarter-wave monopole. A sample of the results for the fan and 5.33-meter whip is shown in figures 6 through 45.

ISOLATION DATA

Degree of isolation between the fan antenna and the 5.33- and 10.67-meter whips, measured with the HP test setup of figure 5, is shown in figures 46 through 57. For 2 and 3 MHz a signal-generator-to-detector method was used, as the dynamic range of the test setup was suspect over 50 dB. The gross isolation for frequencies above 5 MHz was corrected for antenna mismatch loss calculated from the impedance data of figures 2–4 resulting in the space isolation curves shown in figures 58 through 61. The portions of the curves below 5 MHz are dashed; reliable data could not be obtained from the model below 5 MHz due to limitations in measuring accurate impedance data to derive the true mismatch loss. It was hoped that the mismatch loss and also, indirectly, the antenna radiation resistance could be obtained from pattern data at these frequencies by comparison to a $\lambda/4$ antenna, but sufficient accuracy to provide acceptable data was not obtained; at 2 MHz total isolation was less than the antenna mismatch loss while at 3 MHz a space isolation of 4 dB was indicated. Therefore, the dashed portions of the space isolation curves are based on measured isolation between two whips

spaced 12.2 meters apart over a ground plane (fig. 62). This is about the distance between the closest point of the fan to the whip on PHM. It is felt that this represents a worst case — that is, the minimum isolation which might be expected.

ANALYSIS OF ANTENNA MEASUREMENTS

The ability of the antenna system to meet the simultaneous transmission requirement depends, as has been said, on providing sufficient isolation between antennas for satisfactory coupler performance. As shown in figures 58–61, the most critical area is below 10 MHz. Use of the shorter, 5.33-meter whip does provide some additional isolation over most of the frequency range. Also, additional isolation whip to fan will be realized as a result of coupler inefficiency in matching the high-reactance, very-low-resistance impedance of the shorter whip at frequencies below about 7 MHz. Even when an auxiliary external matching coil, necessary for compatibility of the short whip and 490T, is provided, an increased effective isolation is obtained at the expense of lower antenna system efficiency.

The 10.67-meter whip, because of its greater length and correspondingly higher resistive component at the low frequencies, will provide greater antenna system efficiency below 7 MHz. Its use will decrease space isolation, and its greater efficiency could be offset by the need for reducing radiated transmitter power. On the basis of the measurements taken with the 490T coupler and the isolation curves obtained on the model, it appears likely that use of the shorter whip will not guarantee that "tuning holes" (frequencies at which interference between radiating antennas causes malfunction) will not occur.

HERO CONSIDERATIONS

Magnitude of the radiated field in the vicinity of the Harpoon missile launcher and forward gun determines whether a possible hazard exists. The antenna near field in peak volts per meter was determined analytically for both the 10.67- and 5.33-meter whips over a perfect ground plane. Curves showing the expected field at varying heights above ground level and at varying distances from the antenna based on the parameters of figure 63 are shown for both whip lengths in figures 64 to 72. Minimum distance from the whip to the gun is approximately 7 meters. The field at the frequency of maximum field, 2 MHz, is 115 rms volts/meter for the 5.33-meter whip and 81 rms volts/meter for the 10.67-meter whip. Although the data were calculated over a ground plane, they can be applied to the whip case because the hazardous region surrounding the antenna is not a major function of the structure surrounding the antenna.[3] Calculating the field for the fan antenna is a much more difficult problem, because of the complexity of

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[3]NELC Technical Report 1812, "Calculated Near Fields of Navy HF Whip Antennas," by J. W. Rockway and P. M. Hansen, 24 April 1953.

modeling the antenna and the surrounding structure to which it is coupled. A simple model of the fan has been simulated and limited data were obtained for 2 MHz by use of a numerical modeling program based on the sinusoidal interpolation method. At 12.5 meters directly aft of the mast, which is about 9.2 meters aft of the fan feedpoint, the vertical component of the field, 1 meter above the feedpoint, was 120 rms volts/meter for 1 kW radiated. (The vertical field component is by far the major contributor to the total field.) At spacings 3 meters port and starboard of the centerline and the same distance aft, the calculated field was 105 rms volts/meter. When derated for coupler losses, these values will fall below 100 volts/meter.

In conjunction with the analytical program, near-field measurements of full-scale antennas were made in cooperation with Boeing personnel with a Boeing-supplied E-field sensor, the EFS-1/LMT, manufactured by Instruments For Industry, Inc. Near-field readings, 1 meter above the ground plane, on a 10.67-meter whip at several spacings from the whip all were within 20 percent of the analytical values. The same instrument was then used to obtain the near-field values on the full-scale mock-up of the fan antenna previously described. The data are shown in figure 73. Although the values shown in figure 73 are for the field directly aft of the fan, measurements were also taken at 2 MHz in the other three quadrants. Values obtained varied by about 25 percent at the 7.5-meter spacing.

The coupler losses are based on measured losses for the 490T coupler feeding the fan. These were determined by measuring the power out of the transmitter feeding the coupler and comparing it to the power into the antenna as represented by I^2R_{ant}. R_{ant} values used are those of table 1. The value for I was read on an rf ammeter inserted between the 490T and the fan feedpoint.

CONCLUSIONS

1. An hf antenna system for PHM consisting of a fan antenna aft and a whip forward will provide the maximum space isolation obtainable between antennas.

2. Using a short whip, 5.33 meters, forward will provide greater space isolation from the fan but antenna coupler efficiency below 7 MHz will be lower than if a larger, 10.67-meter whip is used.

3. The 5.33-meter whip will require an external loading coil when used with the 490T coupler.

4. Mechanically, the shorter whip, being less flexible, is more suited to the high-speed PHM platform.

5. This antenna study did not determine whether isolation between proposed antennas is sufficient to permit simultaneous operation of both transmitting circuits over the 2–30-MHz range without "tuning holes." From the isolation data taken, it appears probable that some tuning holes will occur below 10 MHz at maximum transmitter power output.

6. On the basis of data in reference 1 of this report, it is concluded that operation with lower transmitter power output will permit simultaneous transmitter operation at potential frequencies of interference.

7. A whip mounted forward as indicated in figure 1 will not be a radiation hazard to the PHM OTO Melara gun.

8. Analytical data and measured data on a full-scale mock-up indicated that the fan will not present a radiation hazard to the Harpoon missile launcher.

RECOMMENDATIONS

1. It is recommended that the fan antenna described in this report be installed on PHM for one hf transceive circuit and a 5.33-meter whip be installed on the port side forward at frame 12.5 for the second hf transceive circuit. A second 5.33-meter whip should be mounted starboard at frame 12.5 for the backup receive circuit.

2. The foundation for the forward port-side whip should be made strong enough that a 10.67-meter whip can be installed at a later time if mechanical considerations permit and an improved coupler becomes available.

3. Near-field measurements of the fan antenna should be made shipboard to verify analytical and measured ground plane results.

APPENDIX: TEST DATA

NOTE

The figures and tables which follow, labeled figures 1-73, were developed by members of NELC Radio Technology Division during the course of this project. They are reproduced without rework in the interests of accuracy and economy.

CONTENTS

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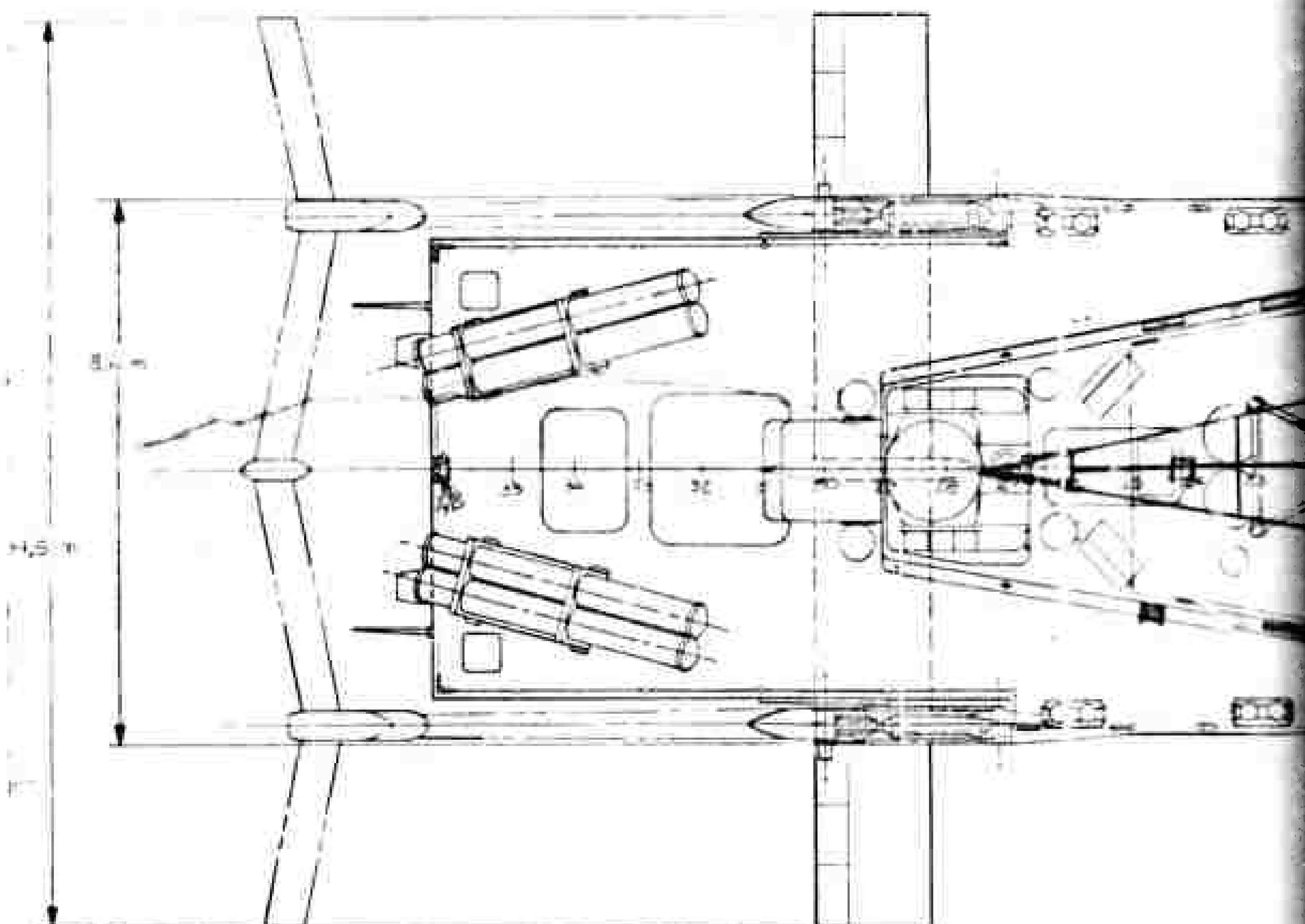
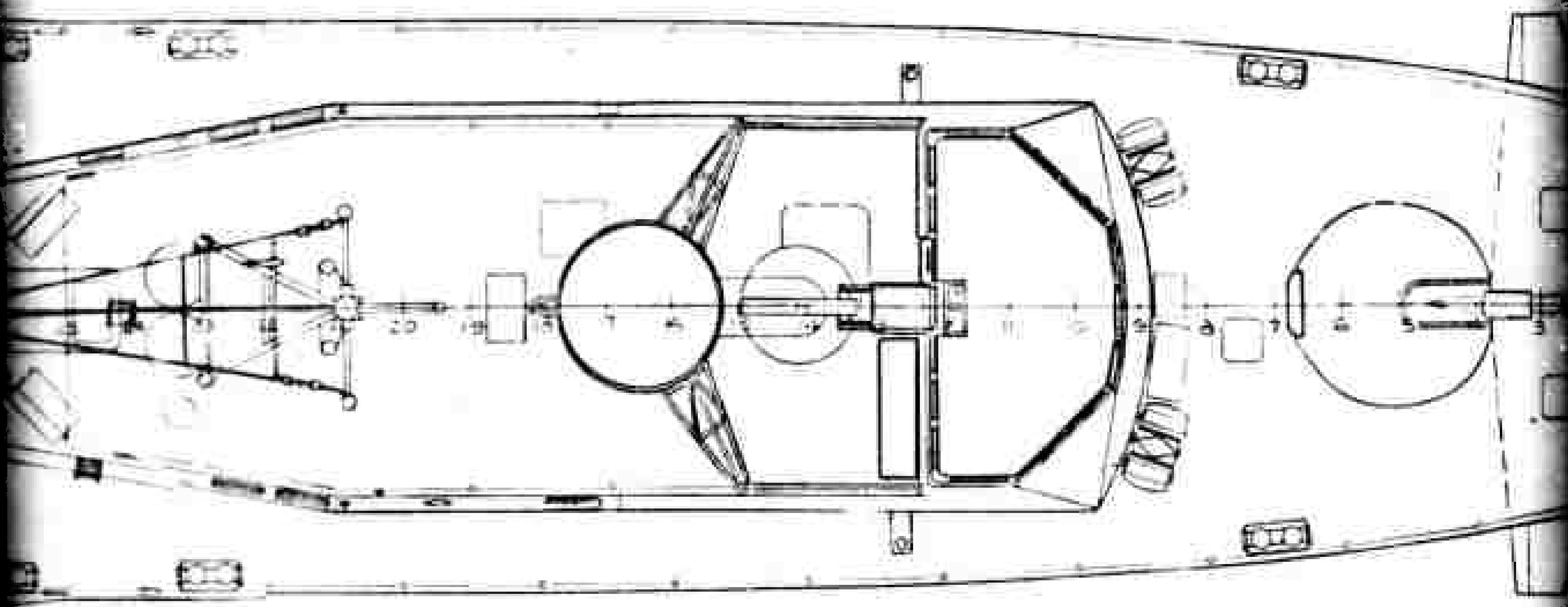
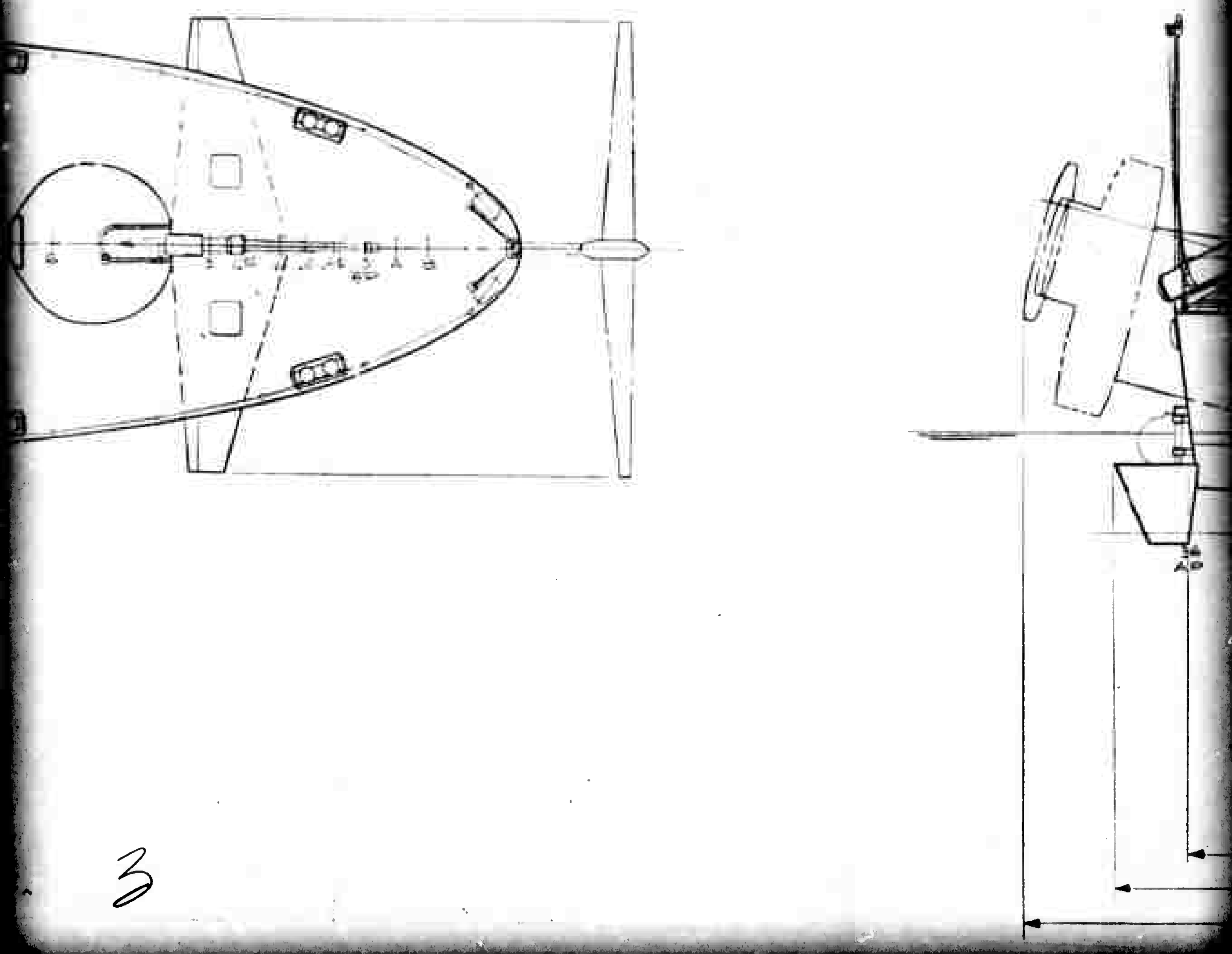




PLAN VIEW

J



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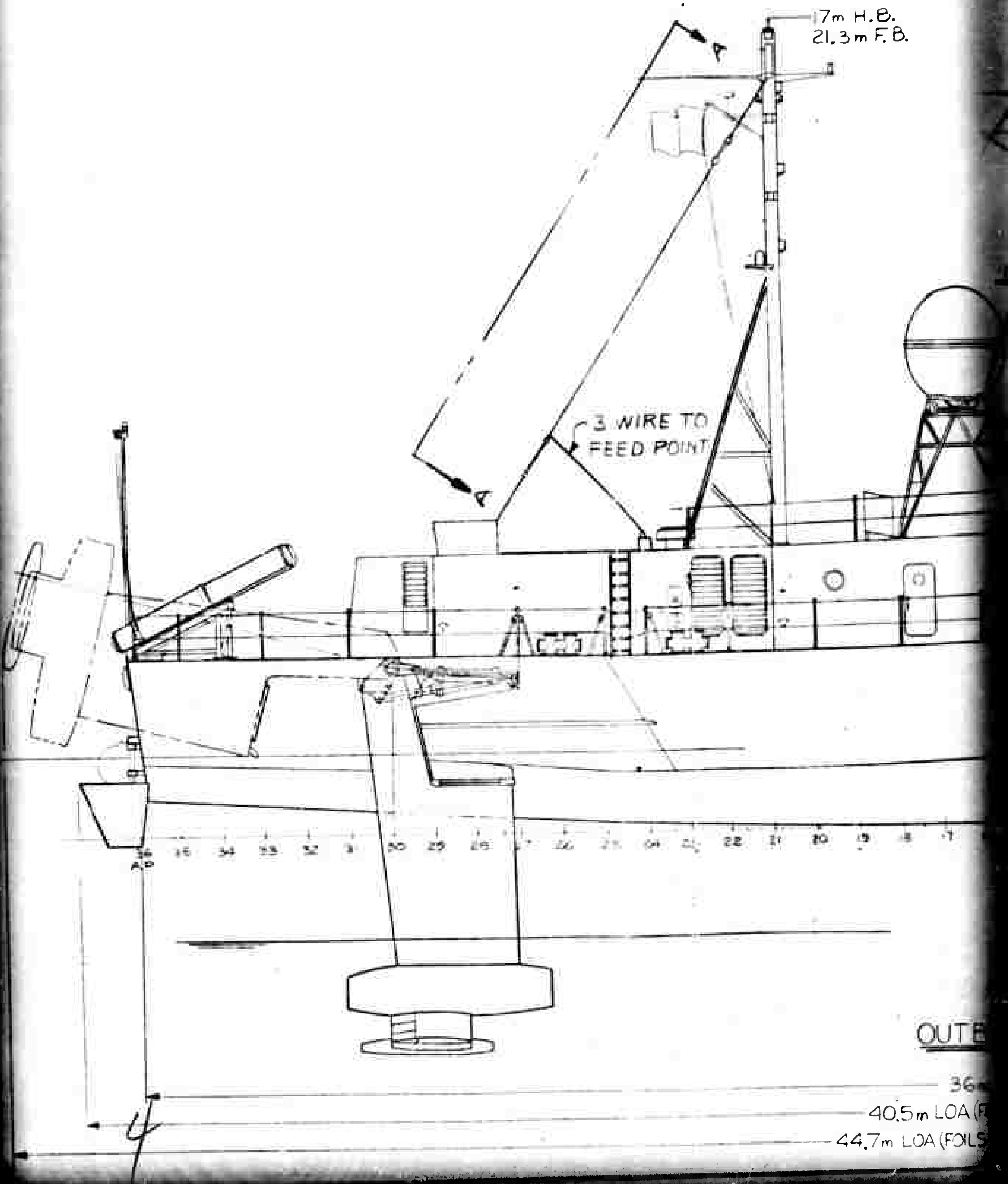

17m H.B.
21.3m F.B.
A
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3 WIRE TO
FEED POINT
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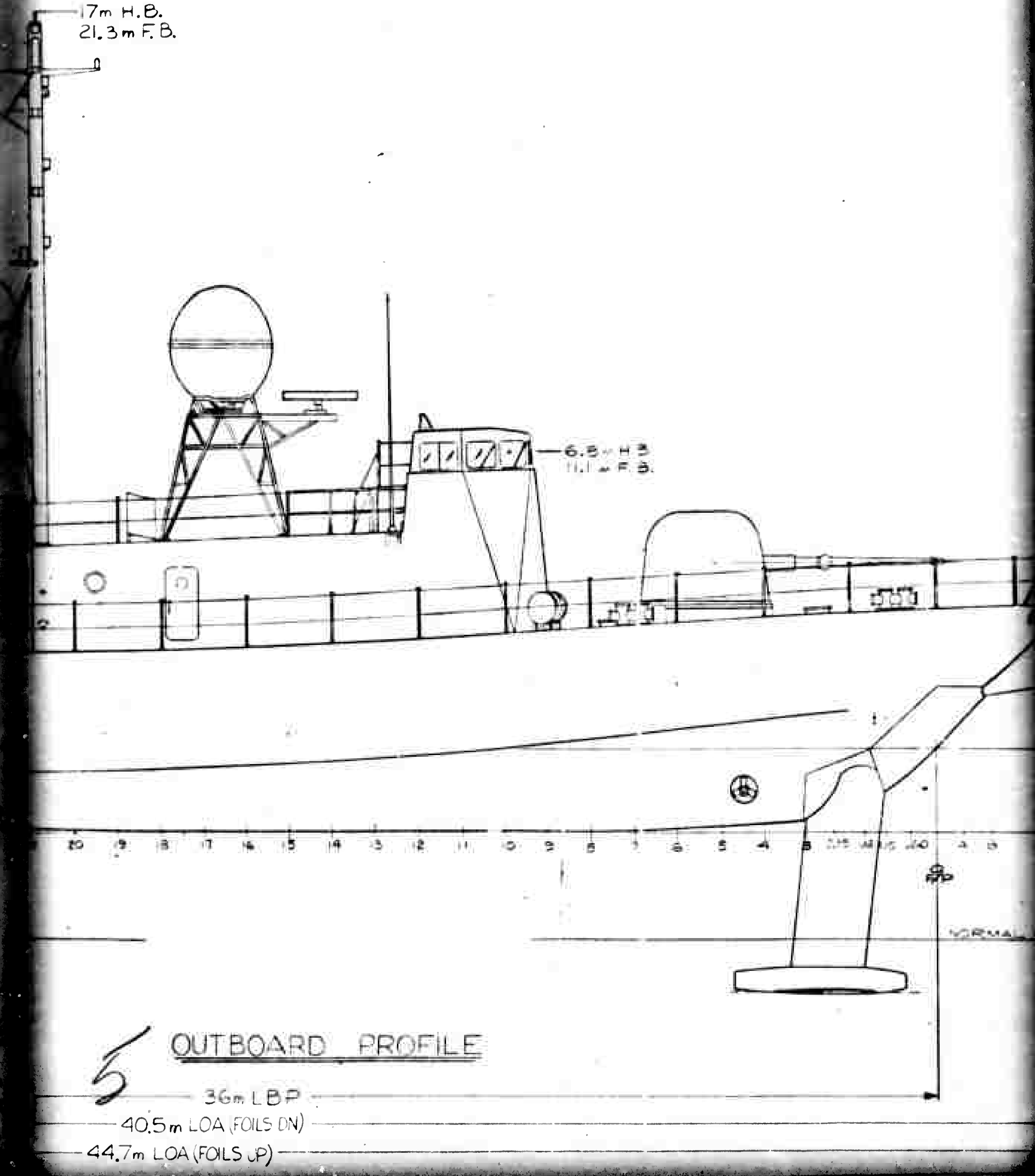
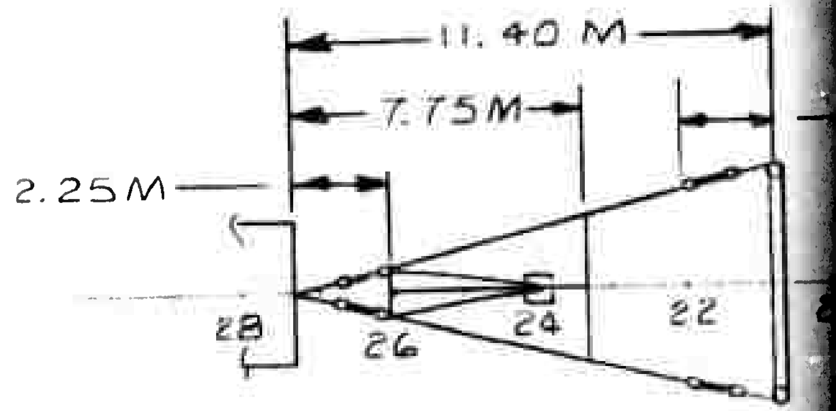


5 OUTBOARD PROFILE



DETAIL AA

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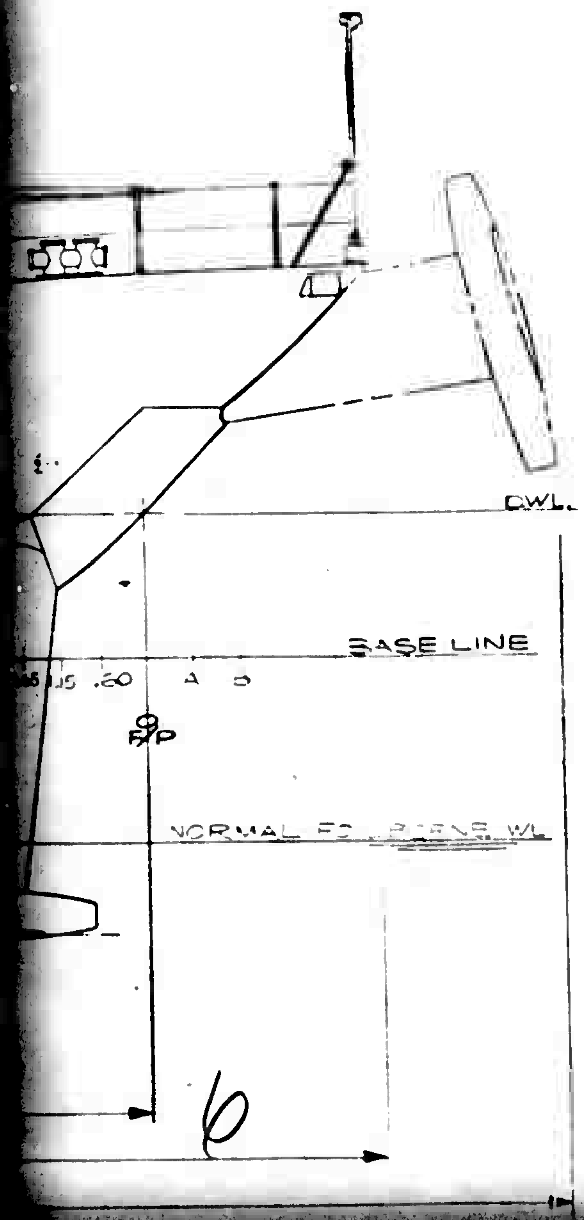
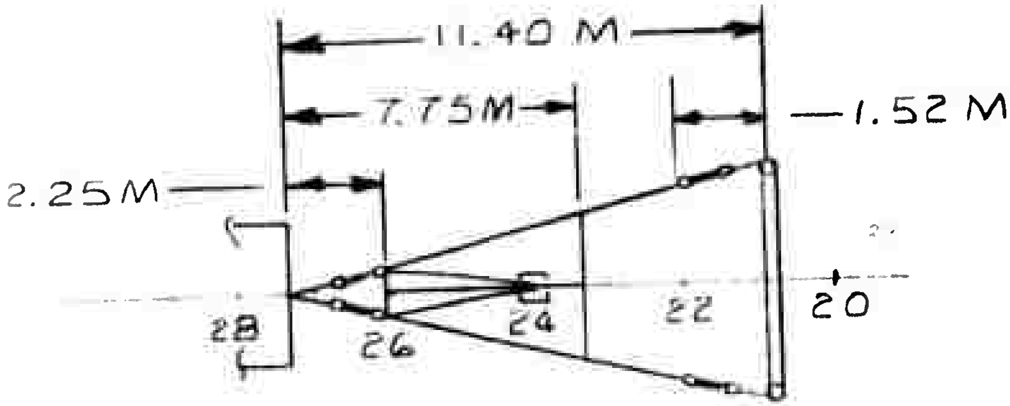


FIGURE 1 PROPOSED H
SYSTEM ARRANGEMENT



DETAIL AA

DIMENSION ARE TRUE LENGTHS

FIGURE 1 PROPOSED HF ANTENNA SYSTEM ARRANGEMENT FOR THE PHM

FREQUENCY IN MHz	FOILBORNE		HULLBORNE	
	R(OHMS)	X(OHMS)	R(OHMS)	X(OHMS)
2	--	-j 350.0	--	-j 275.0
3	--	-j 170.0	--	-j 170.0
4	2.0	-j 82.5	1.5	-j 81.5
5	56.0	+j 26.5	26.5	+j 1.5
6	22.0	+j 26.5	31.0	+j 48.0
7	37.5	+j 89.5	30.0	+j 94.0
8	50.0	+j 173.0	40.0	+j 155.0
9	235.0	+j 300.0	100.0	+j 235.0
10	355.0	+j 15.0	230.0	+j 190.0
11	400.0	-j 50.0	255.0	+j 150.0
12	445.0	-j 150.0	320.0	-j 10.0
13	400.0	+j 80.0	385.0	+j 100.0
14	490.0	-j 200.0	360.0	-j 170.0
15	183.0	-j 175.0	180.0	-j 130.0
16	95.0	-j 90.0	110.0	-j 75.0
17	57.5	-j 55.0	50.0	-j 35.0
18	37.5	0	29.0	+j 10.5
19	57.5	+j 66.0	36.3	+j 57.0
20	60.0	+j 118.0	33.5	+j 70.0
22	112.0	+j 210.0	225.0	+j 200.0
24	270.0	+j 240.0	250.0	+j 288.0
26	155.0	-j 160.0	280.0	-j 95.0
28	125.0	-j 125.0	66.0	-j 70.0
30	93.5	+j 51.0	117.0	-j 22.5

IMPEDANCE OF FAN ANTENNA ON PHM

Figure 2

FREQUENCY IN MHz	FOILBORNE		HULLBORNE	
	R (OHMS)	X (OHMS)	R (OHMS)	X (OHMS)
2	--	-j 500.0	--	-j 440.0
3	--	-j 535.0	--	-j 500.0
4	--	-j 340.0	--	-j 335.0
5	--	-j 240.0	--	-j 250.0
6	7.5	-j 173.0	11.0	-j 190.0
7	15.0	-j 155.0	17.5	-j 172.0
8	19.0	-j 137.0	16.5	-j 124.0
9	8.5	-j 73.0	8.0	-j 71.5
10	23.5	-j 35.0	10.0	-j 31.5
11	23.0	-j 20.0	26.5	+j 4.0
12	35.0	+j 23.5	56.0	+j 20.0
13	44.0	+j 37.0	83.5	+j 55.0
14	125.0	-j 23.0	61.0	-j 13.5
15	48.5	+j 58.0	43.0	+j 75.5
16	71.0	+j 105.0	91.5	+j 121.0
17	73.0	+j 83.5	80.0	+j 119.0
18	350.0	+j 85.0	200.0	+j 140.0
19	180.0	-j 195.0	350.0	-j 120.0
20	270.0	-j 215.0	430.0	-j 135.0
22	150.0	-j 150.0	104.0	-j 145.0
24	40.0	-j 70.0	52.0	-j 78.5
26	45.0	-j 27.5	47.5	-j 25.0
28	34.0	-j 21.0	37.8	-j 10.8
30	25.5	+j 16.3	23.0	+j 10.5

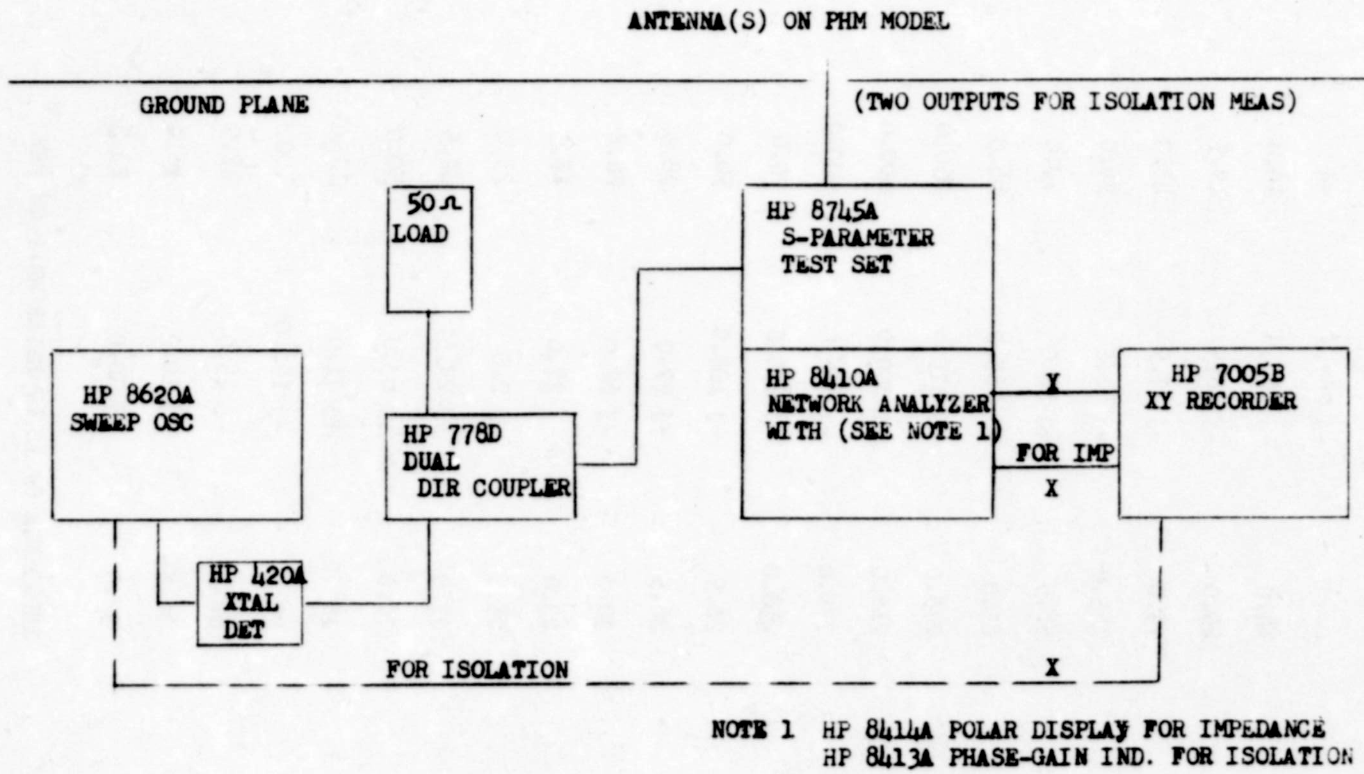
IMPEDANCE OF 5.33 METER WHIP ON PHM

Figure 3

FREQUENCY IN MHz	FOILBORNE		HULLBORNE	
	R (OHMS)	X(OHMS)	R(OHMS)	X(OHMS)
2	--	-j 400.0	--	-j 370.0
3	--	-j 280.0	--	-j 315.0
4	14.0	-j 160.0	10.0	-j 176.0
5	20.0	-j 88.5	19.5	-j 94.5
6	75.0	+j 27.5	43.0	+j 3.8
7	145.0	+j 41.5	96.0	-j 6.0
8	58.5	+j 50.0	70.0	+j 60.0
9	85.0	+j 185.0	84.0	+j 180.0
10	275.0	-j 225.0	250.0	-j 400.0
11	215.0	-j 300.0	600.0	-j 490.0
12	275.0	-j 325.0	400.0	-j 250.0
13	210.0	-j 250.0	70.0	-j 190.0
14	28.5	-j 108.0	50.0	-j 104.0
15	38.5	-j 99.0	28.0	-j 93.0
16	30.0	-j 69.0	28.8	-j 69.0
17	23.0	-j 27.0	18.3	-j 28.0
18	25.5	-j 2.0	25.0	-j 1.0
19	39.0	+j 27.5	32.5	+j 27.0
20	70.0	+j 63.0	50.0	+j 70.0
22	193.0	+j 71.0	125.0	+j 224.0
24	90.0	-j 122.0	100.0	-j 130.0
26	52.5	-j 45.0	48.5	-j 34.0
28	38.8	-j 10.0	36.0	+j 10.0
30	32.0	+j 30.0	23.5	+j 27.5

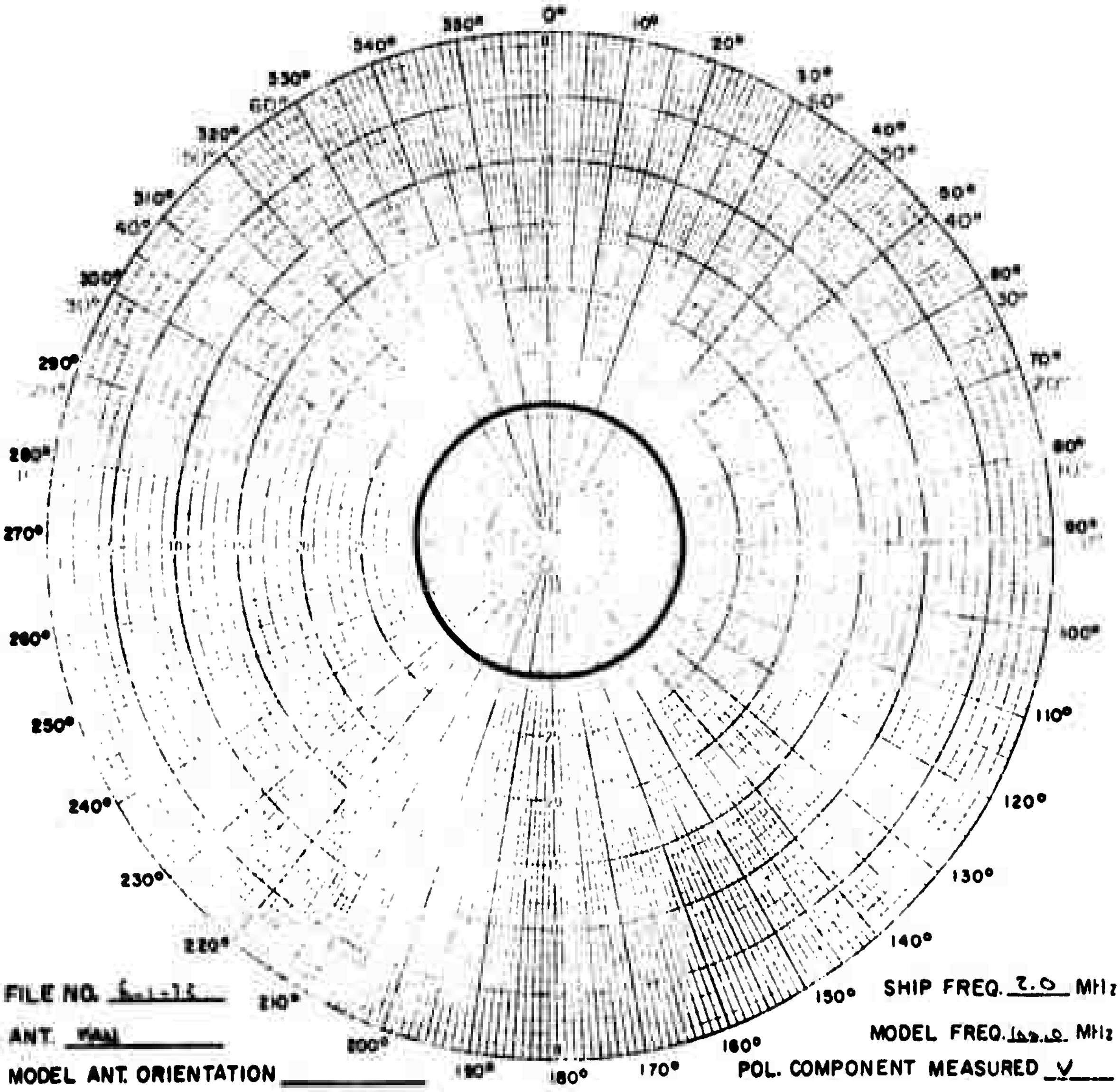
IMPEDANCE OF 10.67 METER WHIP ON PHM

Figure 4



TEST SETUP FOR MEASURING ANTENNA IMPEDANCE AND ISOLATION ON PHM

Figure 5



FILE NO. [illegible]

ANT. [illegible]

MODEL ANT. ORIENTATION ______

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 2.0 MHz

MODEL FREQ. [illegible] MHz

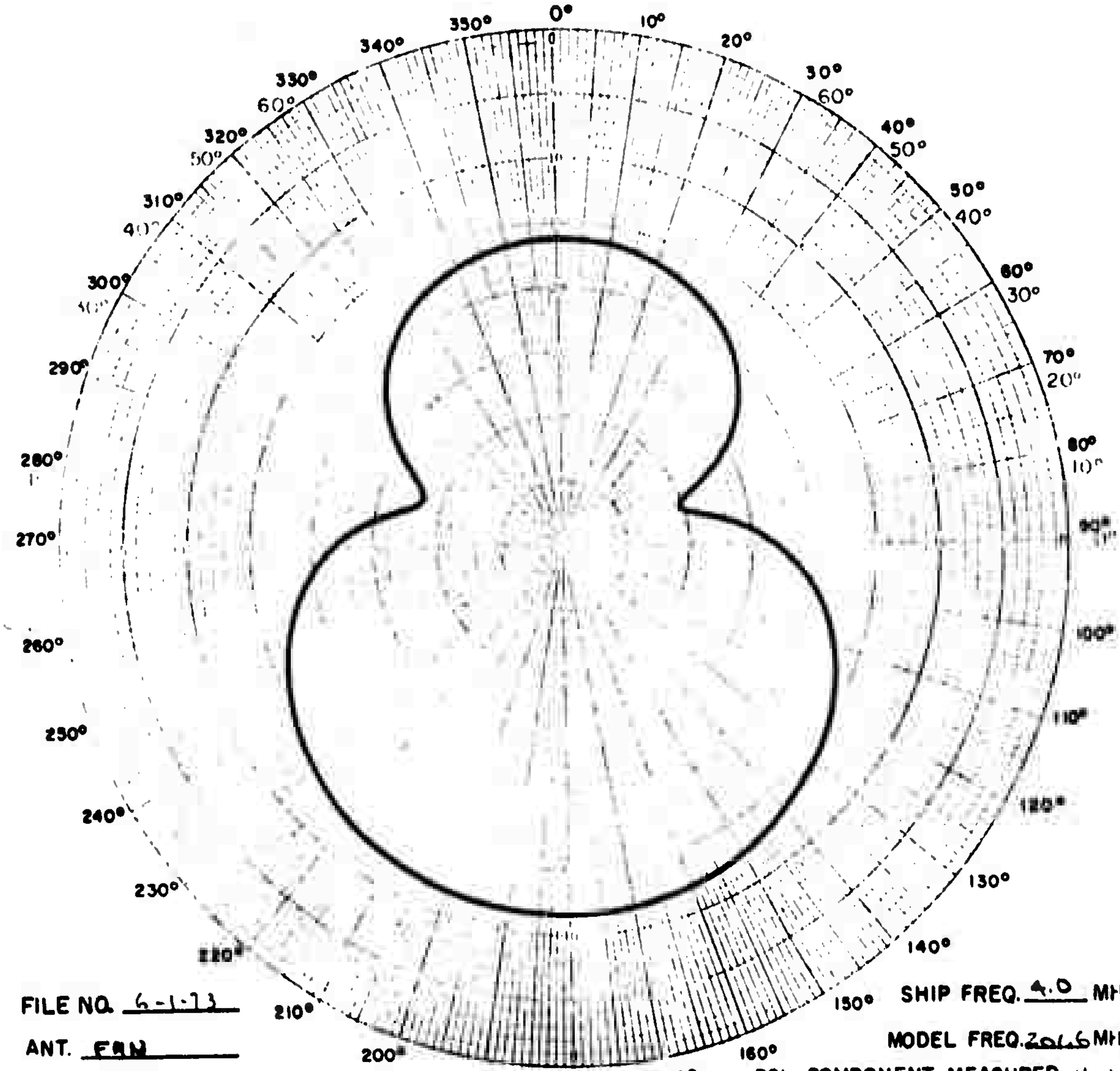
POL. COMPONENT MEASURED V

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS [illegible] HULLBORNE

ENGR ______ DATE 6 JUNE 73

Figure 6



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SHIP FREQ. 4.0 MHz

ANT. FRN

MODEL FREQ. 201.6 MHz

MODEL ANT. ORIENTATION ____

POL. COMPONENT MEASURED V

AZIMUTH PATTERN AT 5 DEG. ELEV.

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

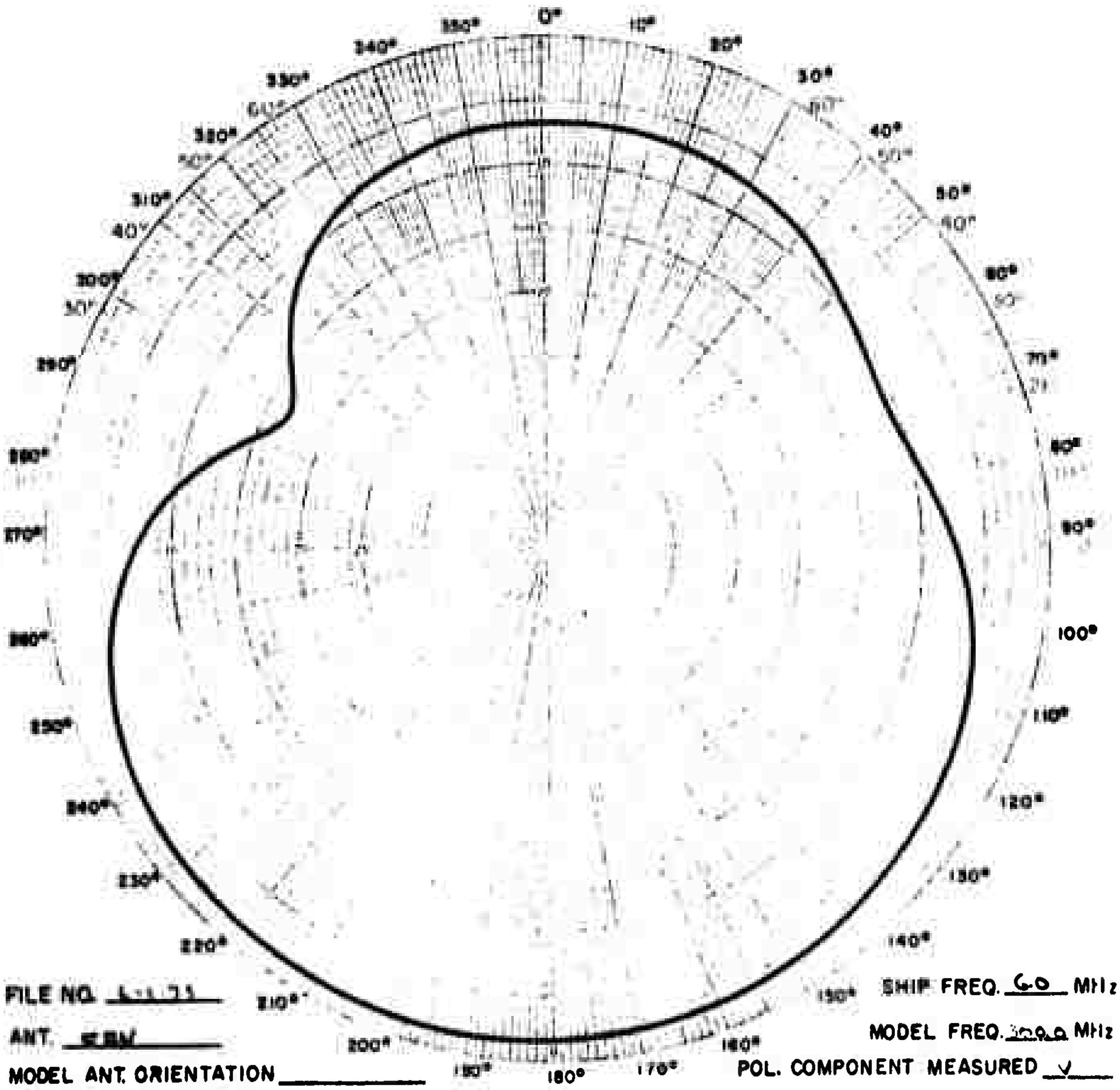
ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

REMARKS PHM/ HULLBORNE

ENGR ____ DATE 6 JUNE 73

Figure 7



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ANT. ______

SHIP FREQ. 60 MHz

MODEL FREQ. 3000 MHz

MODEL ANT. ORIENTATION ______

POL. COMPONENT MEASURED V

AZIMUTH PATTERN AT 5 DEG. ELEV.

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

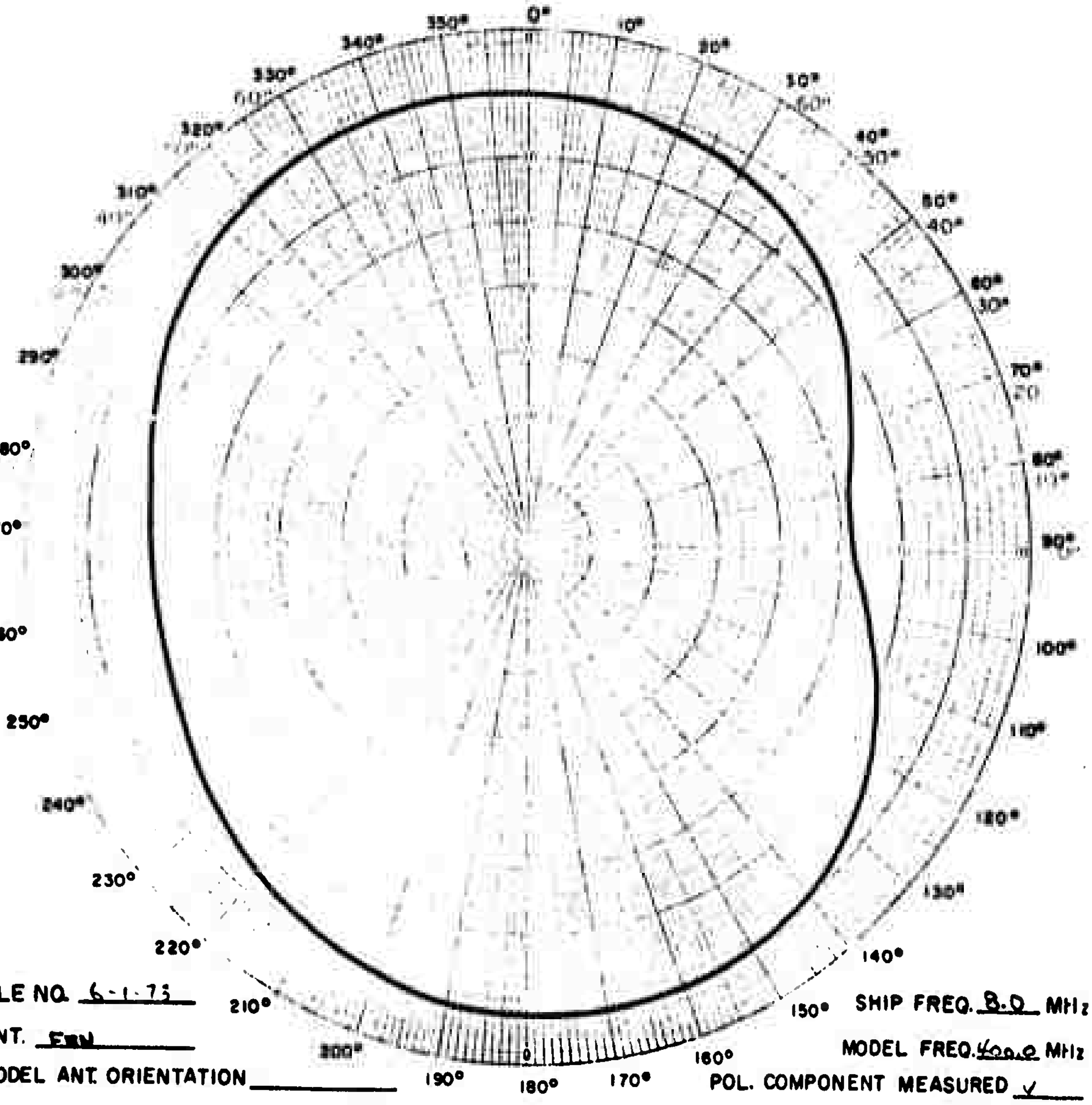
ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

REMARKS PHM / HULLBORNE

ENGR ______ DATE 7 JUNE 73

Figure 8



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ANT. FBN

MODEL ANT. ORIENTATION ________

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 8.0 MHz

MODEL FREQ. 400.0 MHz

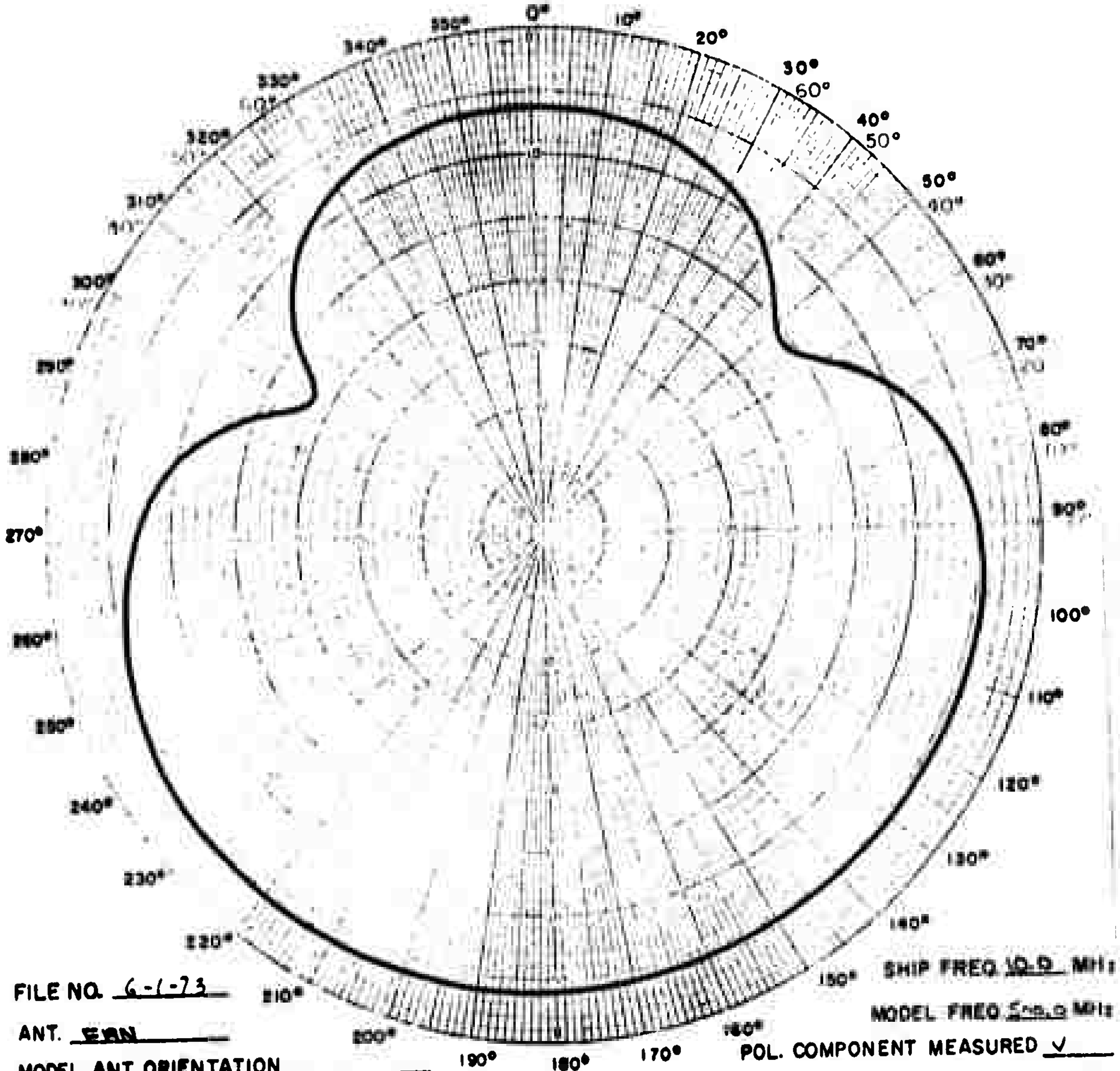
POL. COMPONENT MEASURED ✓

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS Pun / Hullborne

ENGR ________ DATE 7 June 73

Figure 9



FILE NO. 6-1-73

SHIP FREQ 10.0 MHz

ANT. ERN

MODEL FREQ 500.0 MHz

MODEL ANT. ORIENTATION ________

POL. COMPONENT MEASURED V

AZIMUTH PATTERN AT 5 DEG. ELEV.

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

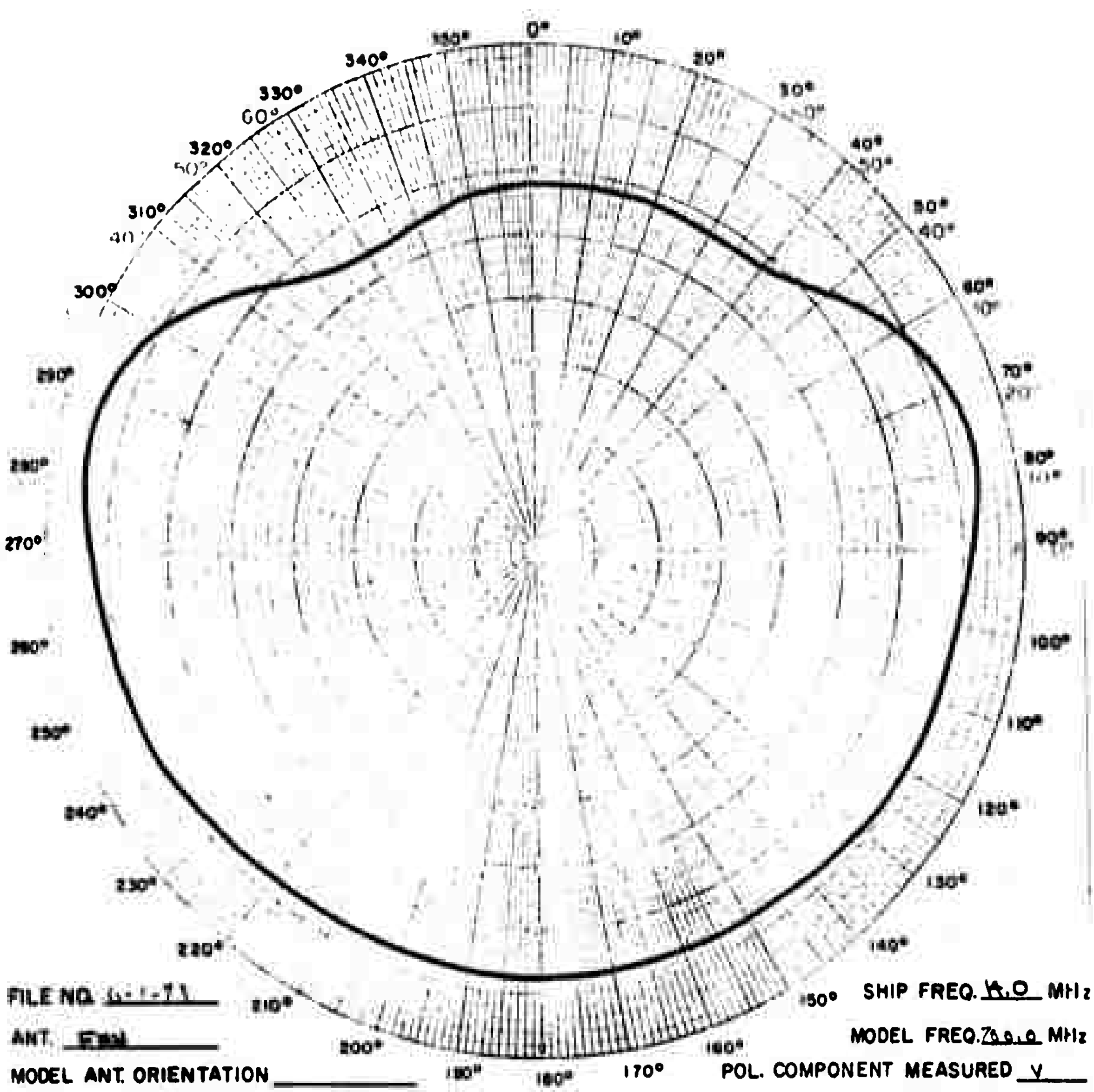
ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

REMARKS PUM / HULLBORNE

ENGR ________ DATE 7 JUNE 73

Figure 10



FILE NO. 6-1-73 SHIP FREQ. 16.0 MHz

ANT. [illegible] MODEL FREQ. 700.0 MHz

MODEL ANT. ORIENTATION ________ POL. COMPONENT MEASURED V

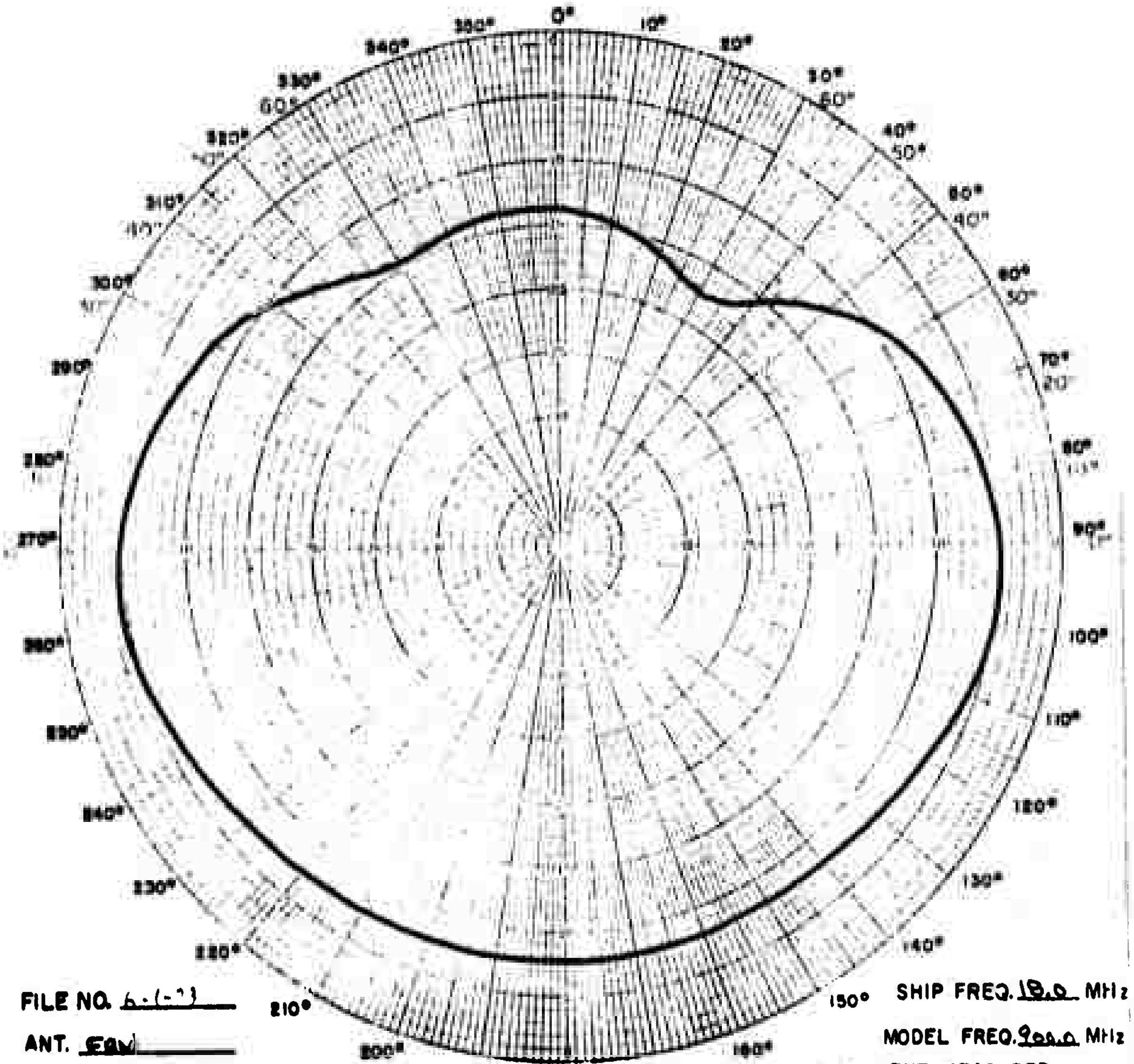
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PWM; HULLBORNE

ENGR ________ DATE 7 June 73

Figure 11



FILE NO. 6-(-1) SHIP FREQ. 18.0 MHz

ANT. FAW MODEL FREQ. 900.0 MHz

MODEL ANT. ORIENTATION _____ POL. COMPONENT MEASURED V

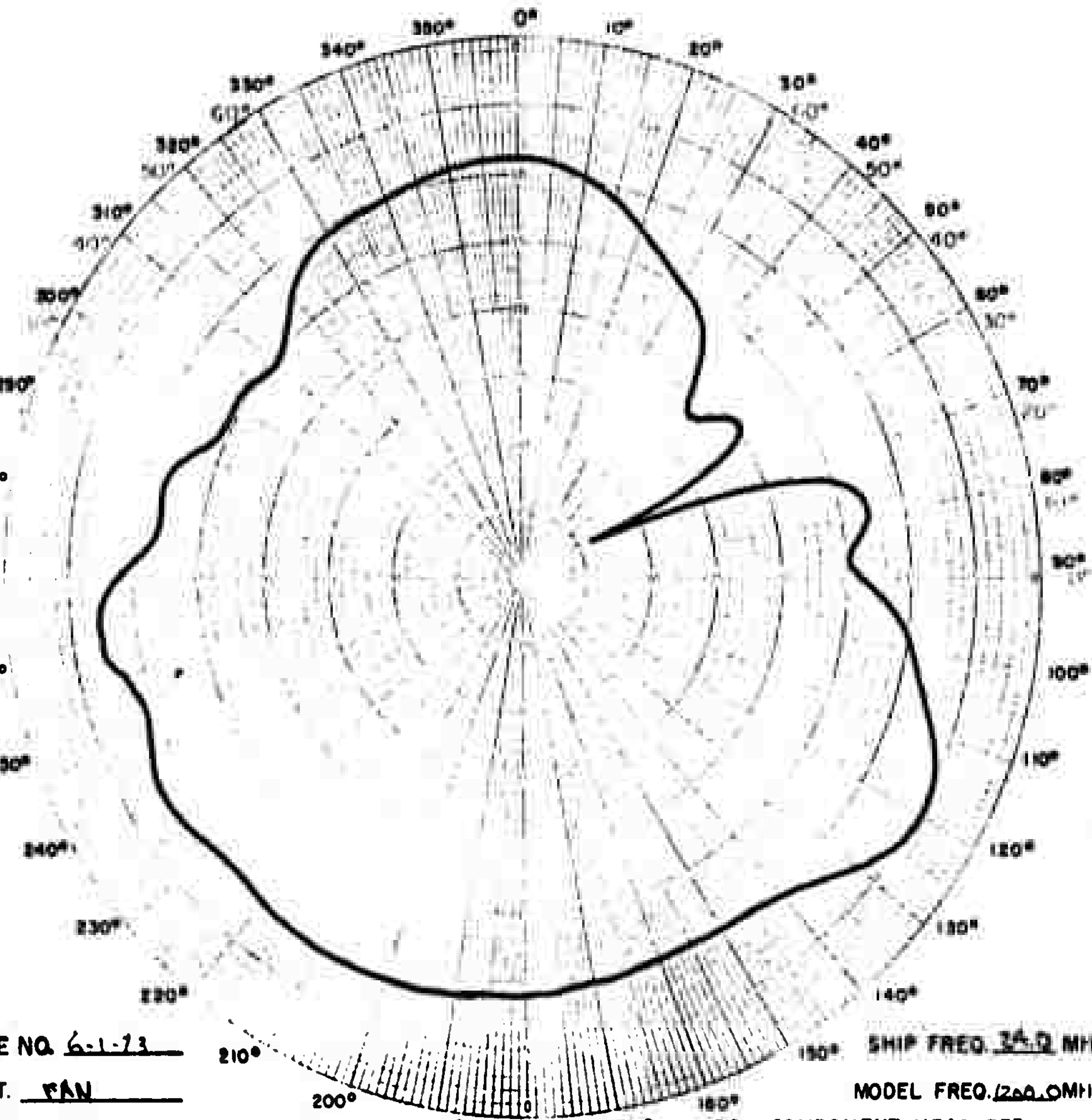
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = ±5 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM/ HULLBORNE

ENGR _____ DATE 7 June 72

Figure 12



FILE NO. 6-1-73 SHIP FREQ. 34.0 MHz

ANT. FAN MODEL FREQ. 1200.0 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED V

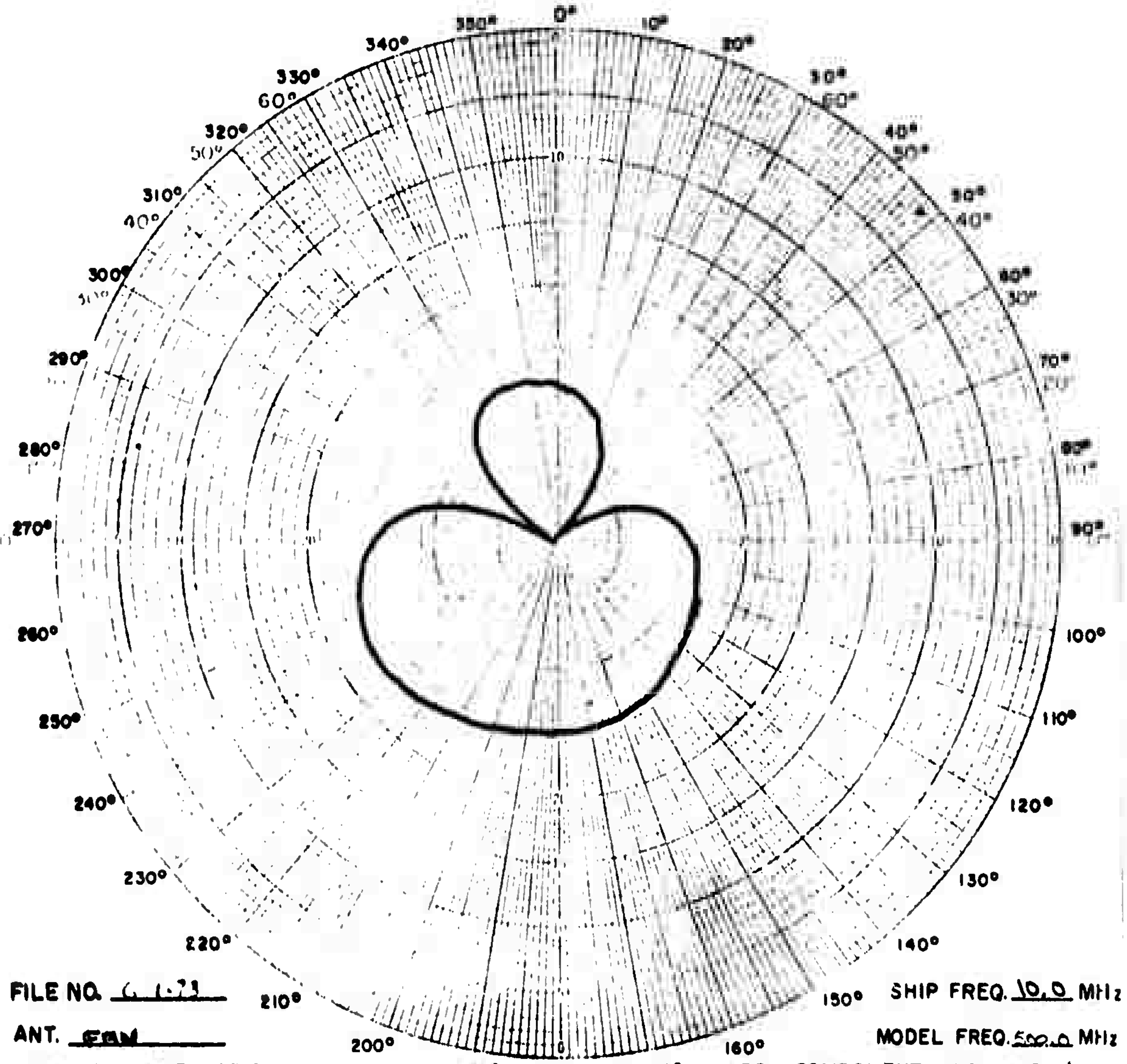
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM / HULLBORNE

ENGR ________ DATE 7 June 73

Figure 13



FILE NO. 6-1-73

ANT. FAM

MODEL ANT. ORIENTATION ________

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 10.0 MHz

MODEL FREQ. 500.0 MHz

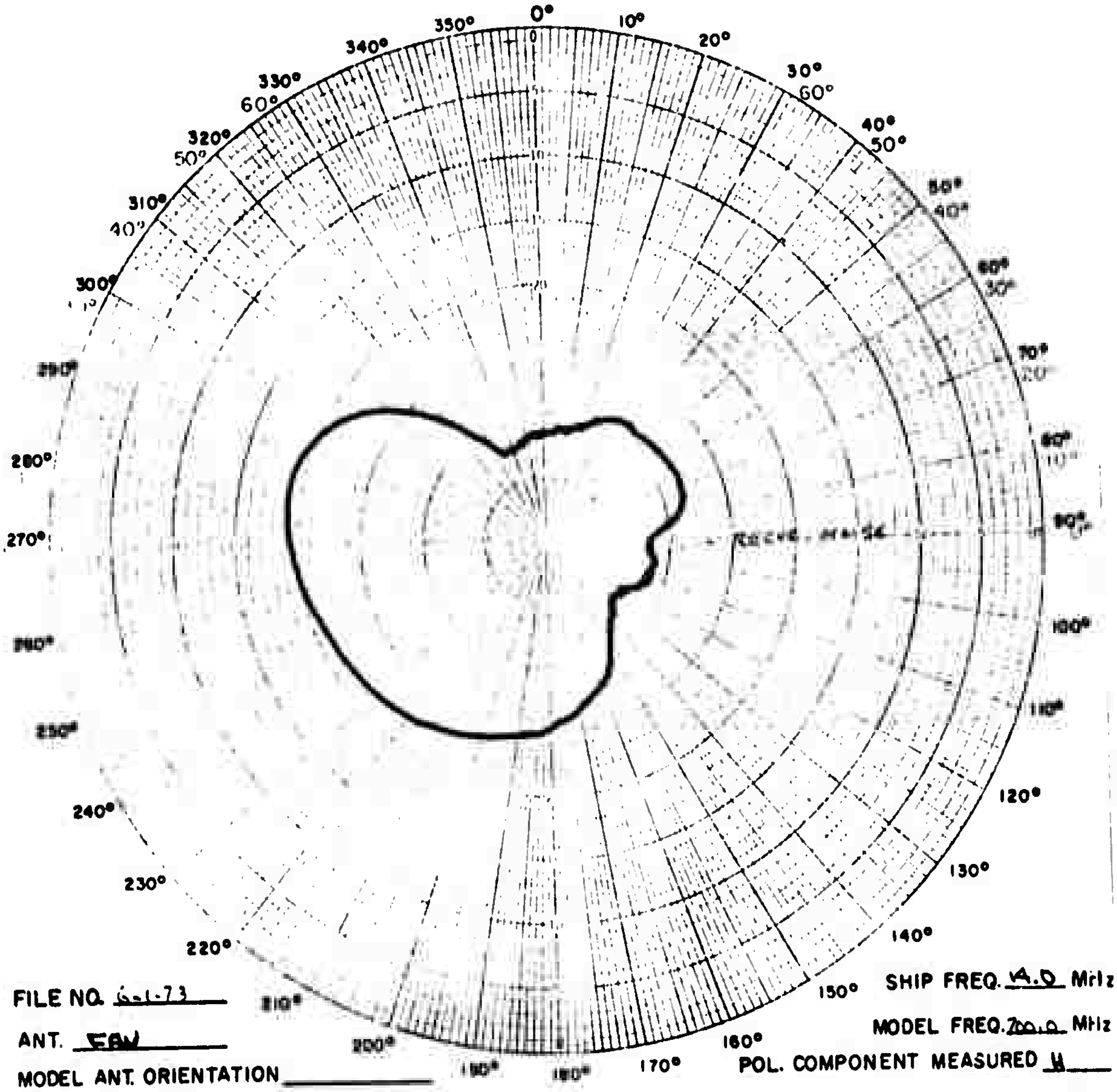
POL. COMPONENT MEASURED H

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS PHM, HULLBORNE

ENGR ________ DATE 7 JUNE 73

Figure 14



FILE NO. 6-1-73

ANT. FAN

MODEL ANT. ORIENTATION ______

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ______ TO ______ DEG.

AT ______ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 14.0 MHz

MODEL FREQ. 200.0 MHz

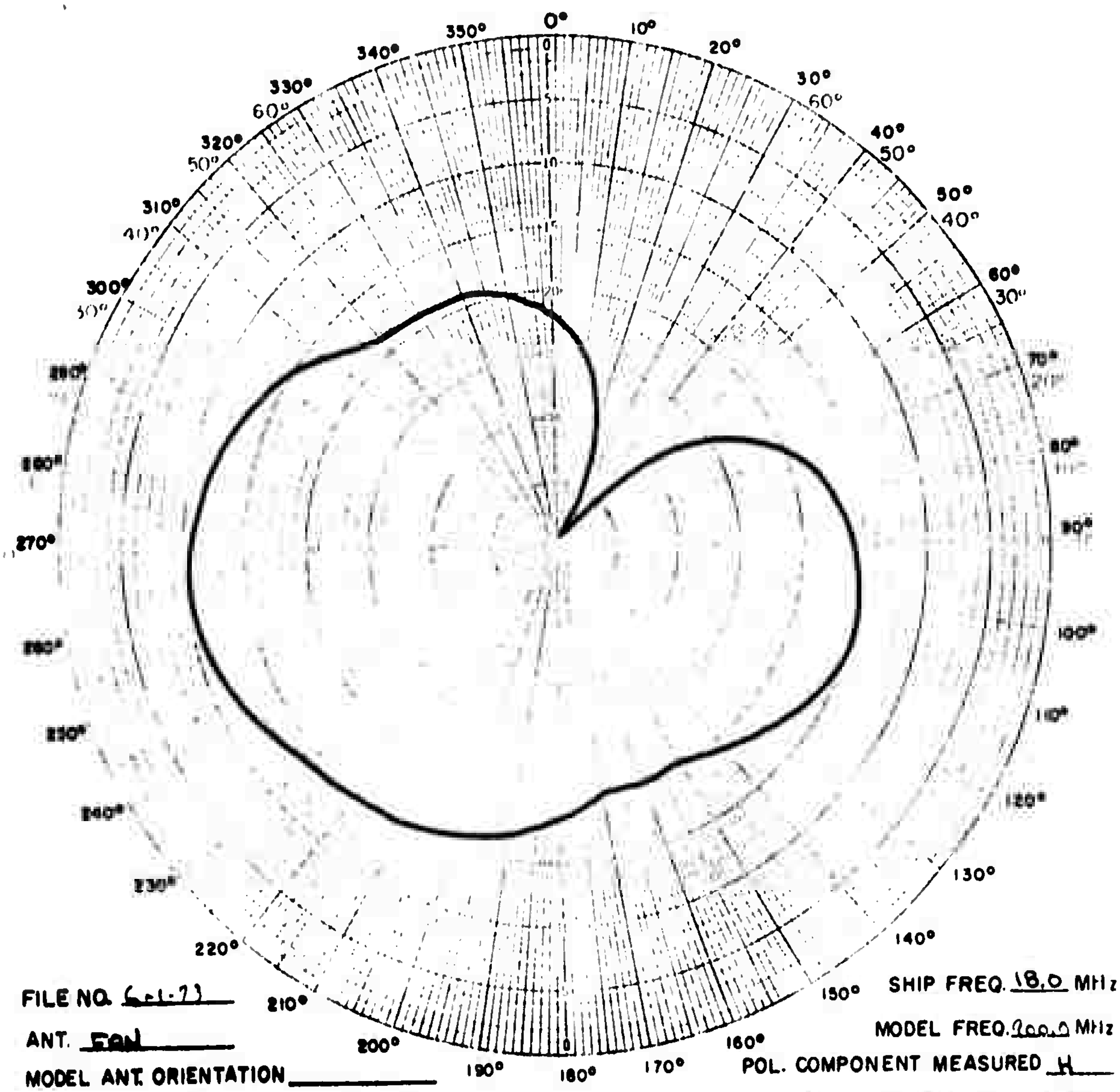
POL. COMPONENT MEASURED H

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS PHM / HULLBORNE

ENGR ______ DATE 7 June 7?

Figure 15



FILE NO. 6-1-73

ANT. FAN

MODEL ANT. ORIENTATION ____

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 18.0 MHz

MODEL FREQ. 300.0 MHz

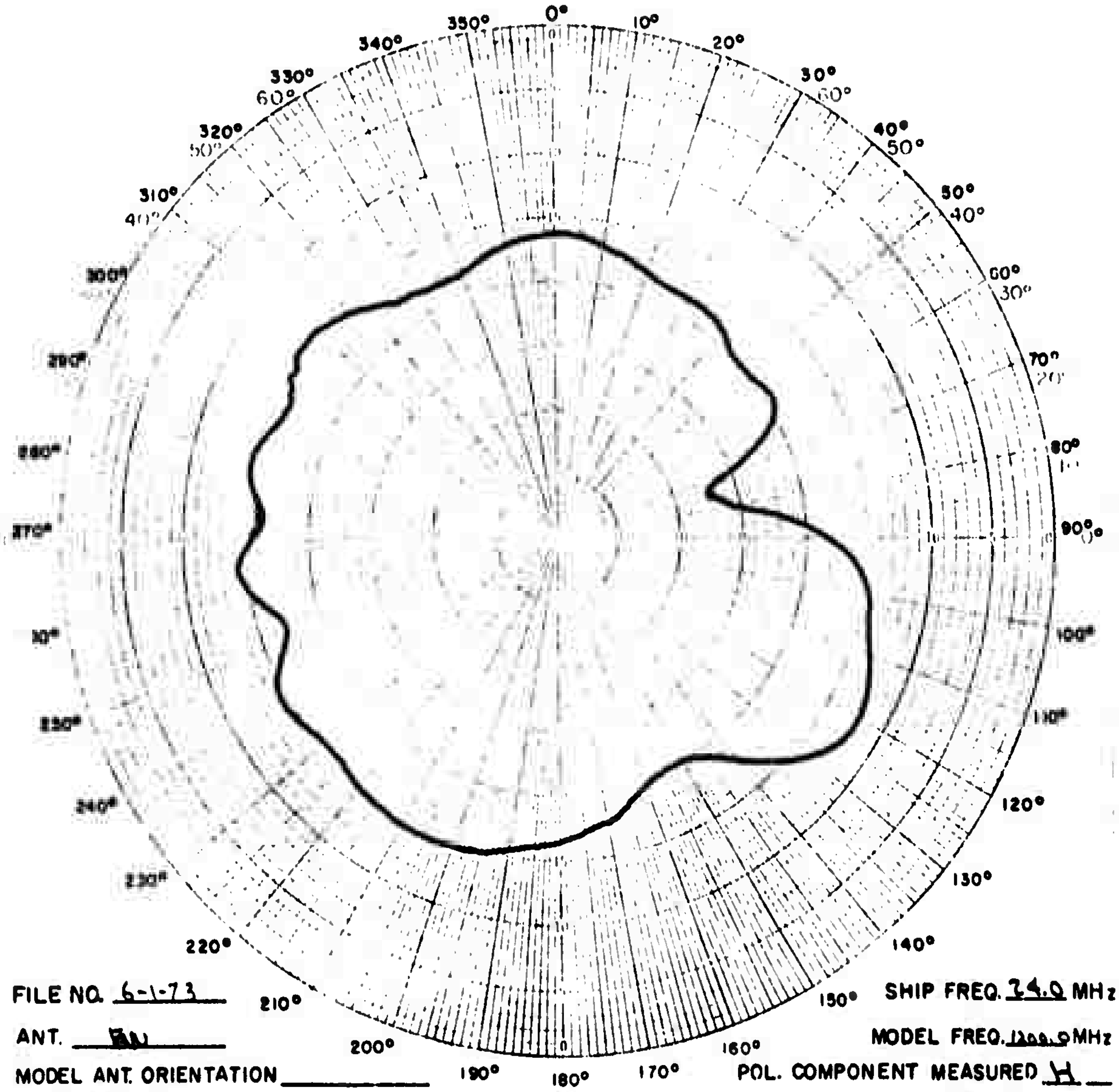
POL. COMPONENT MEASURED H

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS CHM / HULLBORNE

ENGR ____ DATE 7 JUNE 73

Figure 16



FILE NO. 6-1-73 SHIP FREQ. 34.0 MHz

ANT. BN MODEL FREQ. 1200.0 MHz

MODEL ANT. ORIENTATION ________ POL. COMPONENT MEASURED H

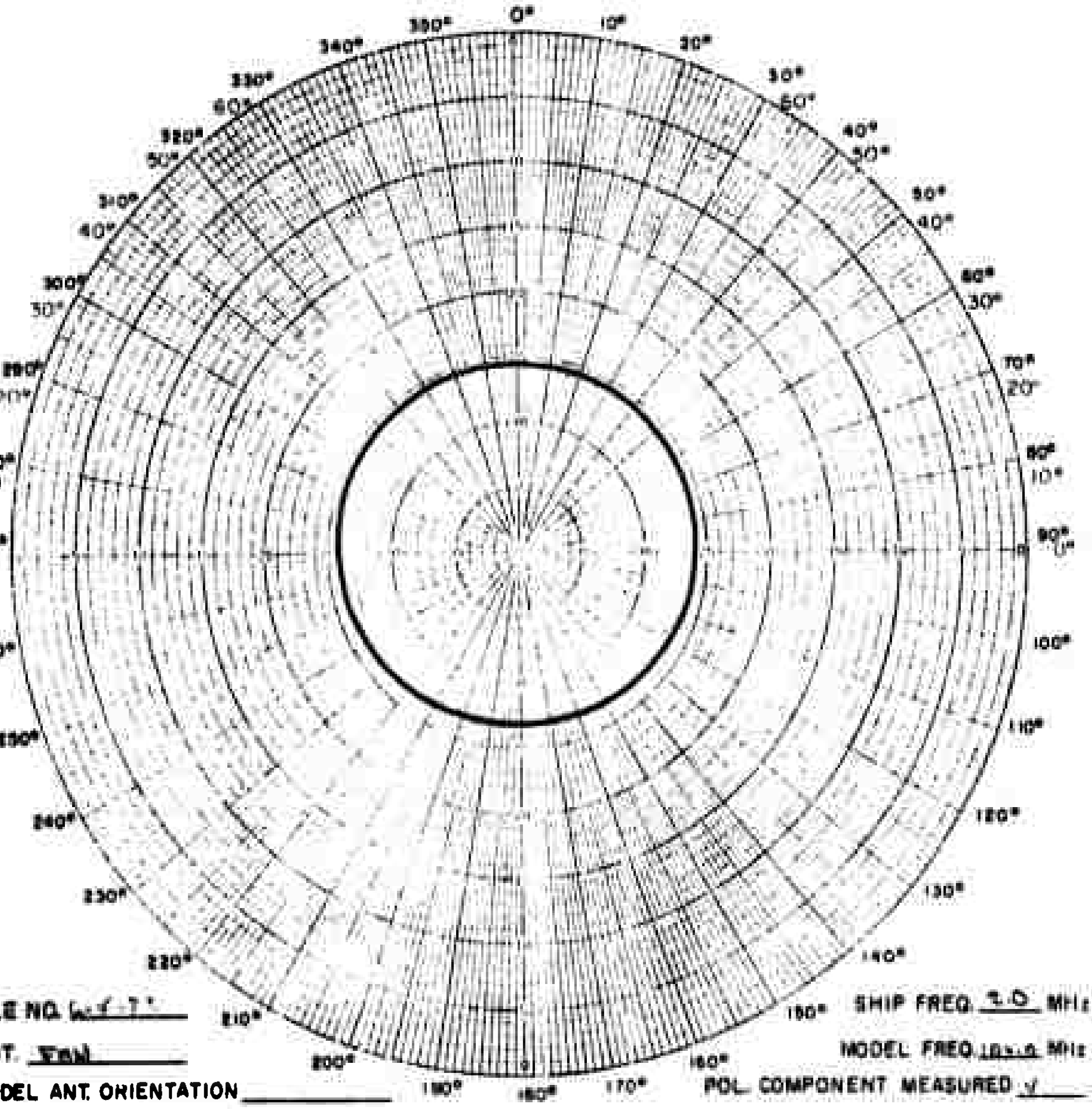
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN _____ TO _____ DEG.

AT _____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM/ HULLBORNE

ENGR ________ DATE 7 JUNE 73

Figure 17



FILE NO. 6-1-73

ANT. FAN

MODEL ANT. ORIENTATION

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 3.0 MHz

MODEL FREQ. 183.6 MHz

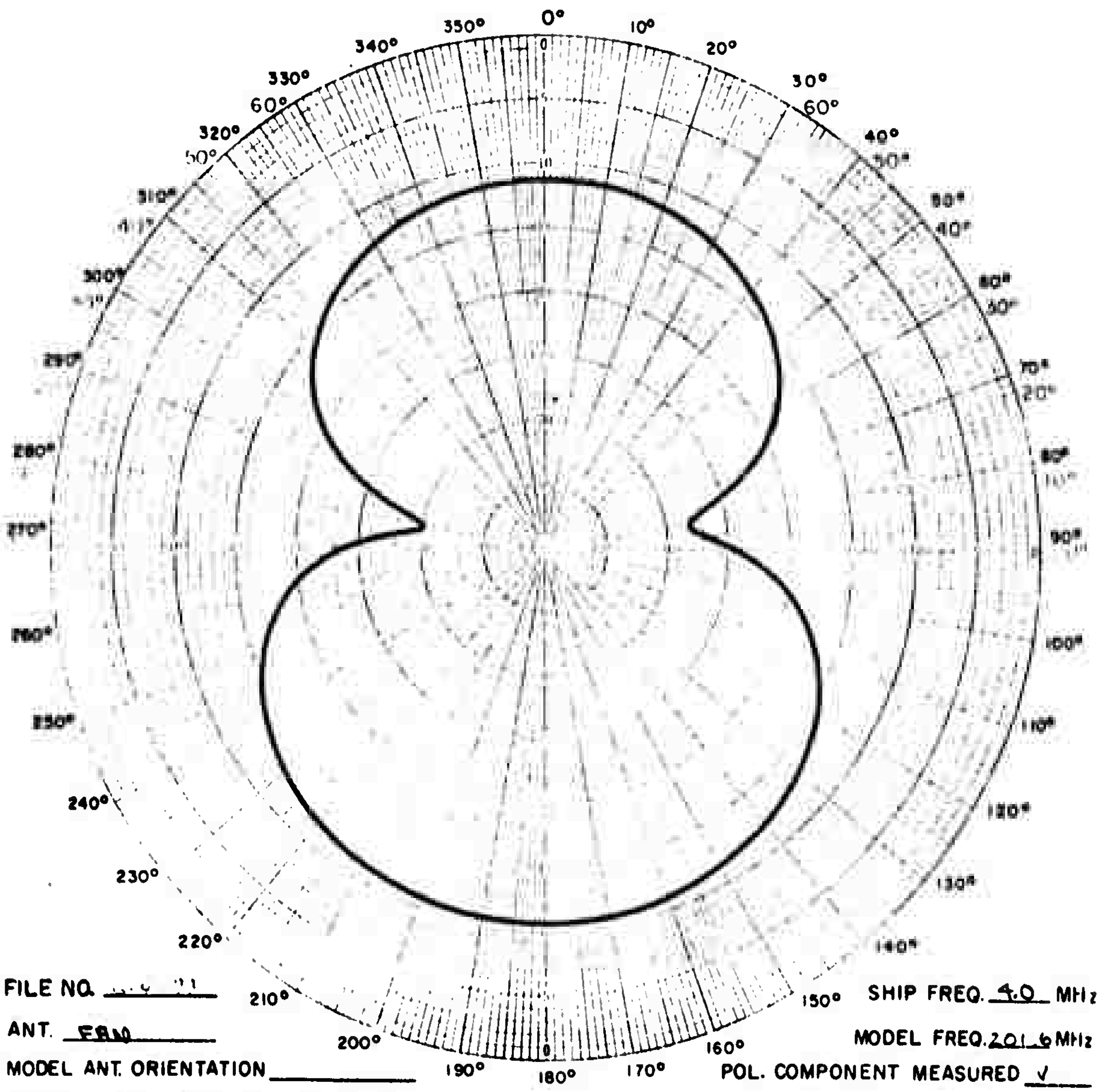
POL. COMPONENT MEASURED V

0 dB ON CHART = 0.0 dB REL. TO $\lambda/4$ MONOPOLE

REMARKS PHM, FOILBORNE

ENGR ________ DATE 6-19-73

Figure 18



FILE NO. ______ SHIP FREQ. 4.0 MHz

ANT. FRW MODEL FREQ. 201.6 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED V

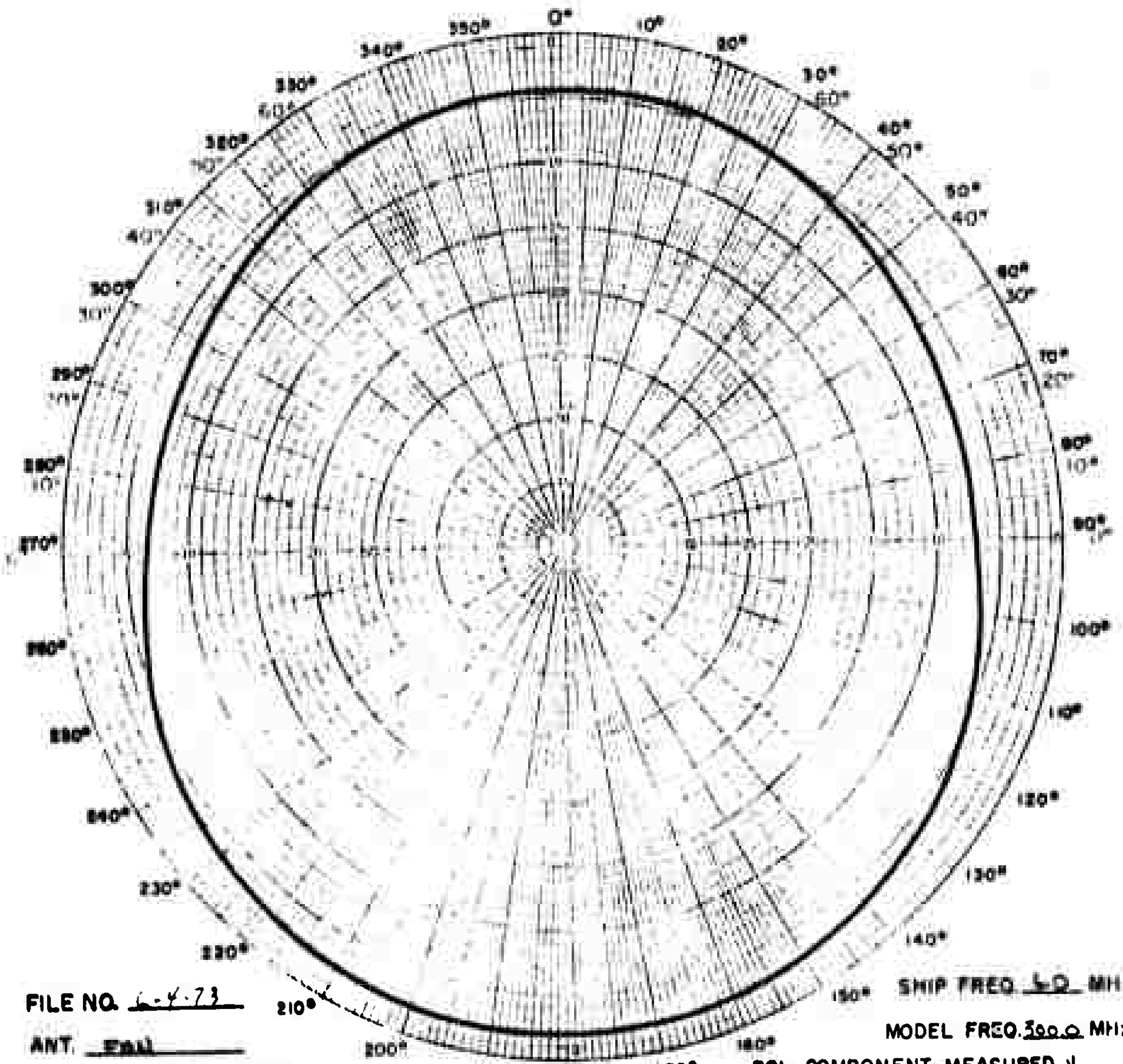
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM / FOILBORNE

ENGR ______ DATE 6-19-73

Figure 19



FILE NO. 6-4-73

ANT. Fwd

MODEL ANT. ORIENTATION ____

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 6.0 MHz

MODEL FREQ. 300.0 MHz

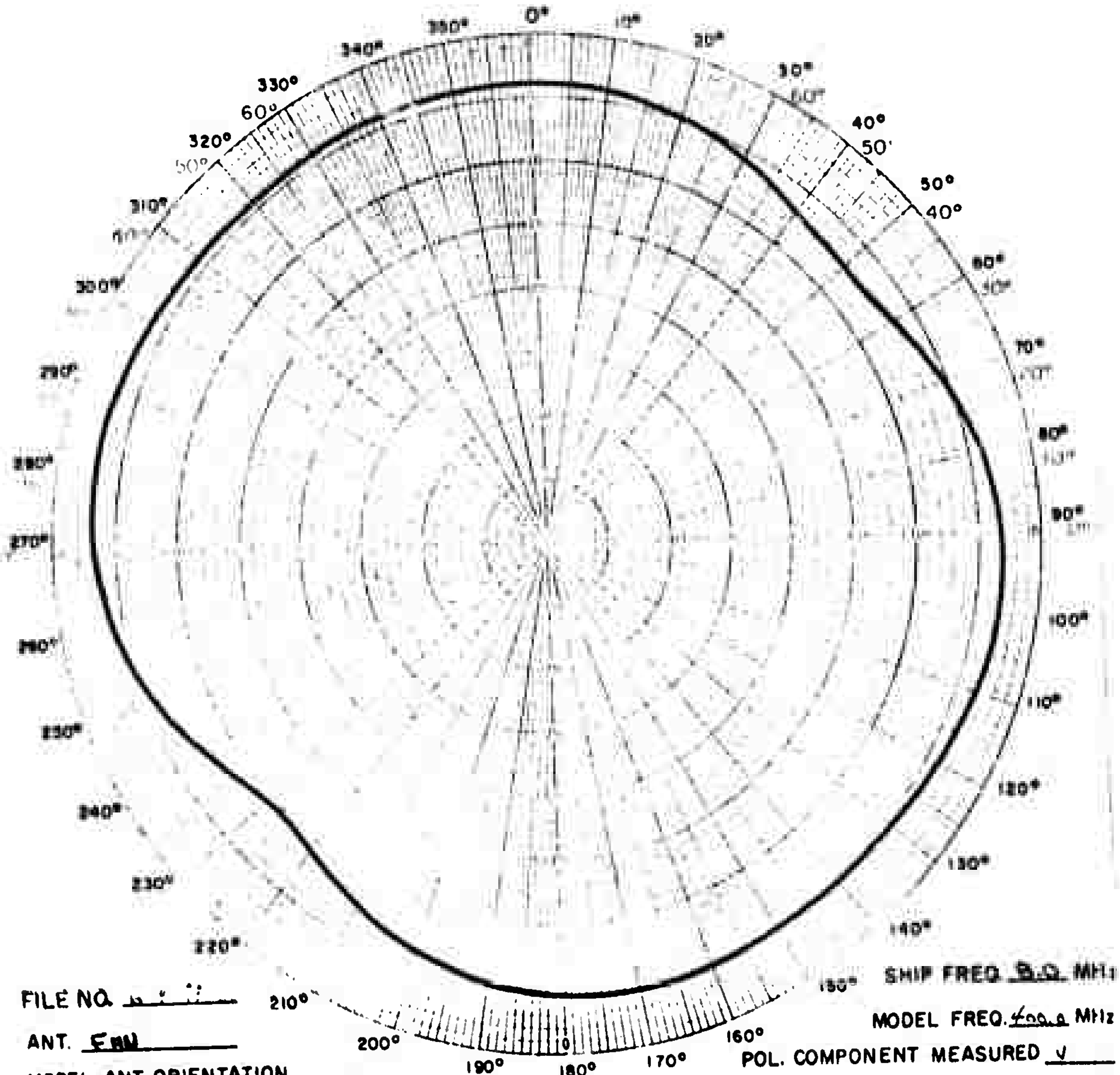
POL. COMPONENT MEASURED V

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS Plum / Following

ENGR ____ DATE 6-19-73

Figure 20



FILE NO. ______

ANT. FAN

MODEL ANT. ORIENTATION ______

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ 8.0 MHz

MODEL FREQ. 400.0 MHz

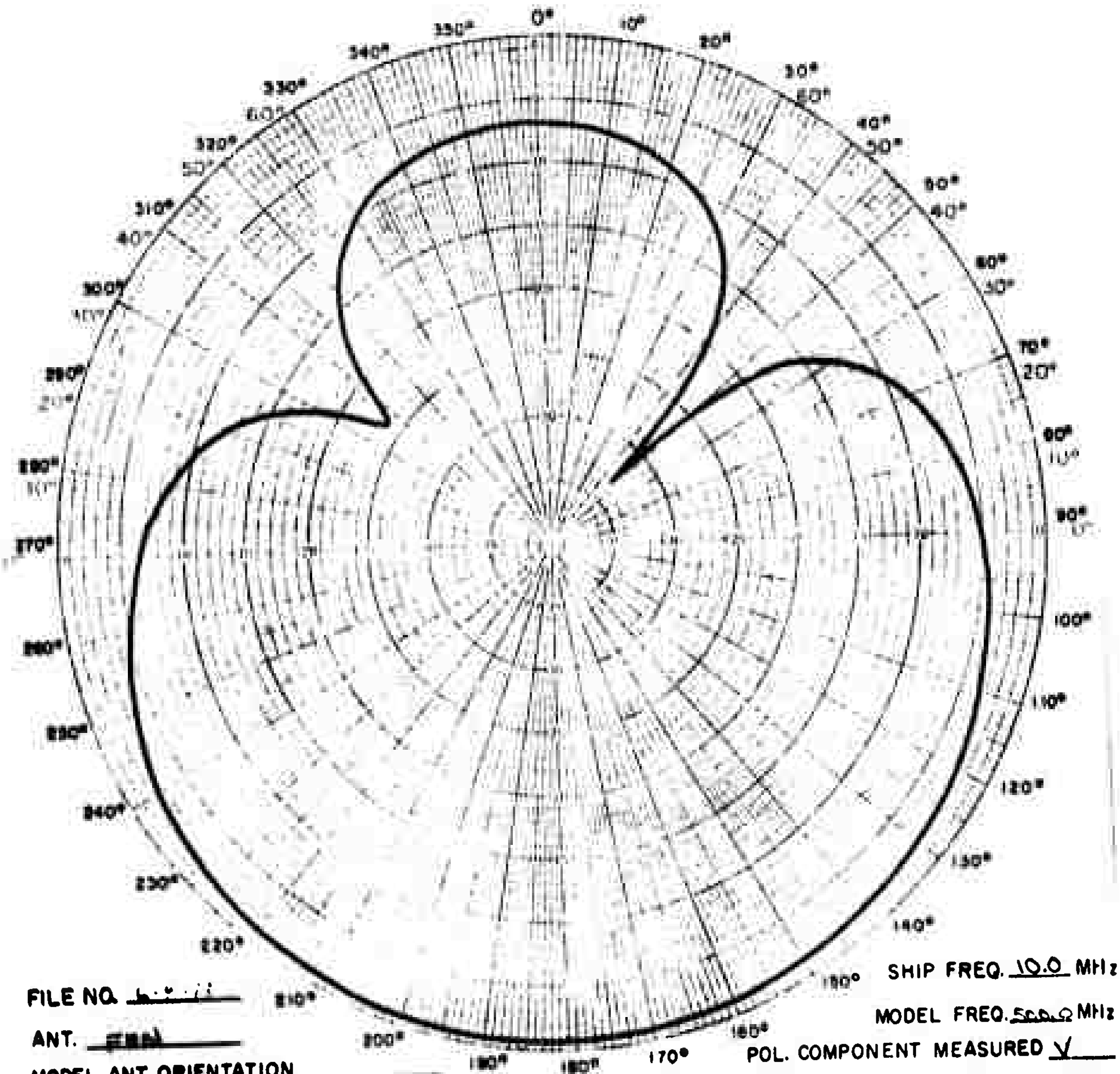
POL. COMPONENT MEASURED V

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS CHM / FOLLBORNE

ENGR ______ DATE 6-19-73

Figure 21



FILE NO. ______

ANT. ______

MODEL ANT. ORIENTATION ______

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ______ TO ______ DEG.

AT ______ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 10.0 MHz

MODEL FREQ. 500.0 MHz

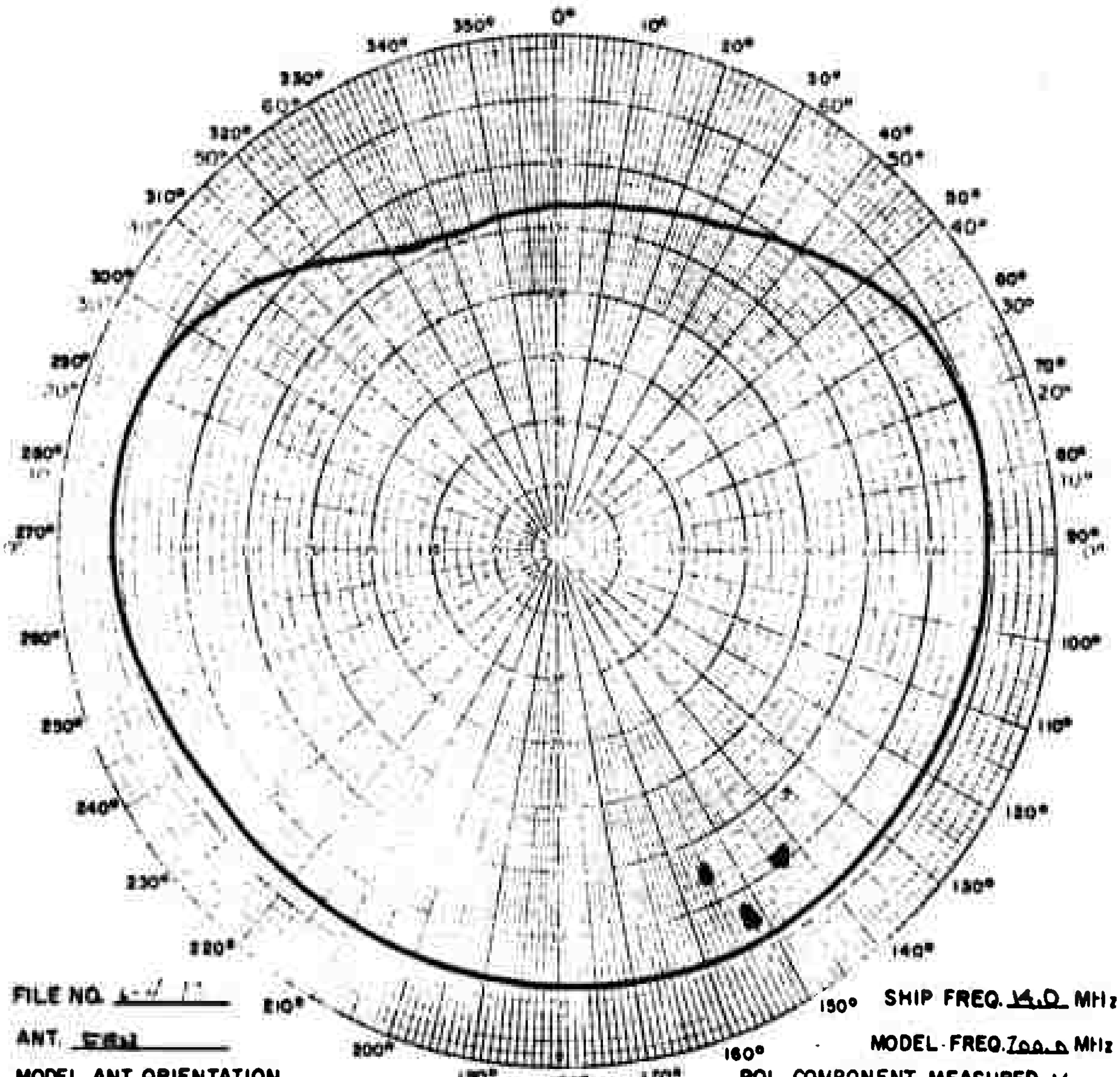
POL. COMPONENT MEASURED V

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS RUM/ FOILBORNE

ENGR ______ DATE 6-19-73

Figure 22



FILE NO. [illegible] SHIP FREQ. 14.0 MHz

ANT. [illegible] MODEL FREQ. 700.0 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED V

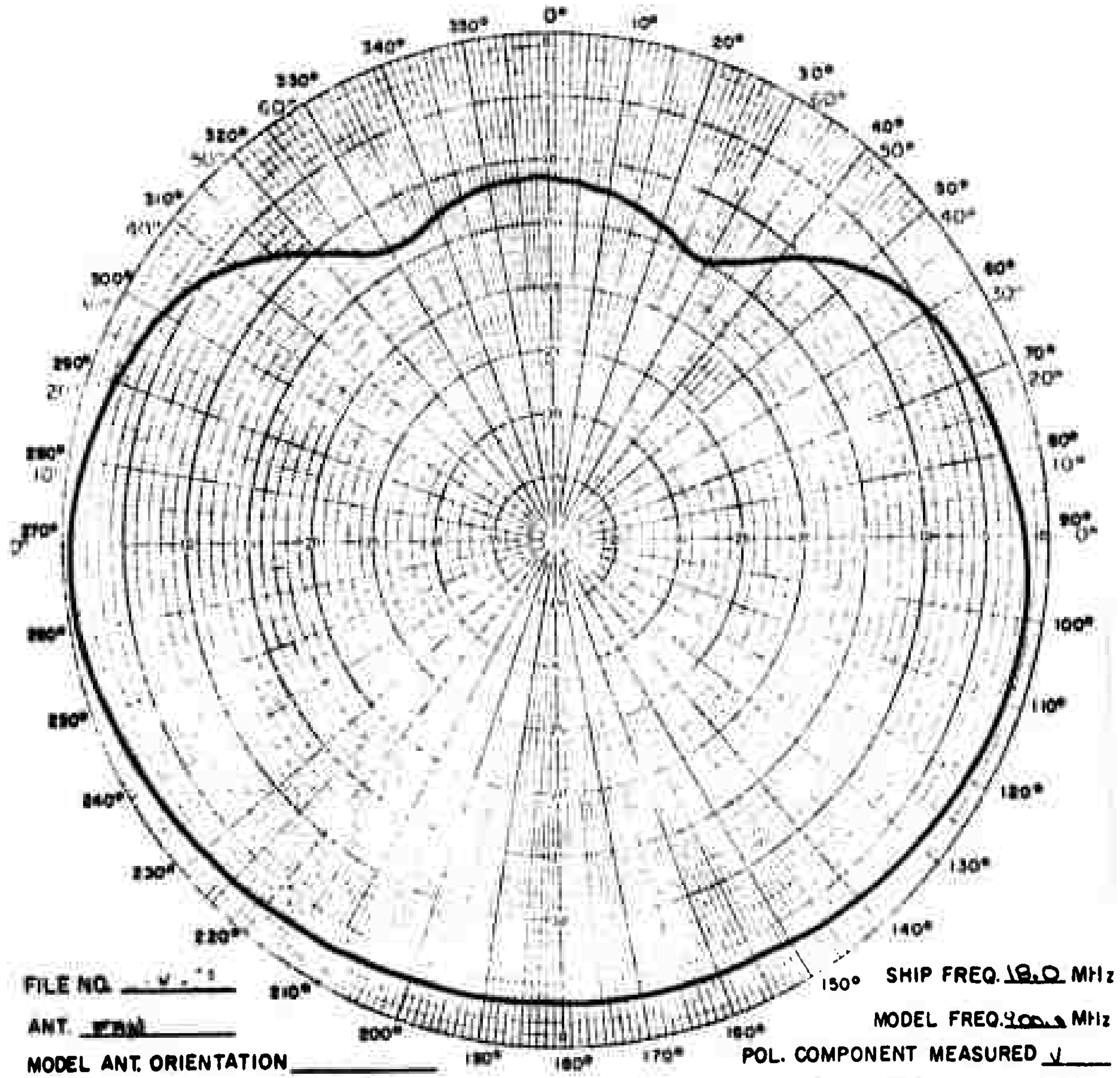
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS RHM/FOILBORNE

ENGR ______ DATE 6-19-73

Figure 23



FILE NO. ______ SHIP FREQ. 18.0 MHz

ANT. ______ MODEL FREQ. 400.0 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED V

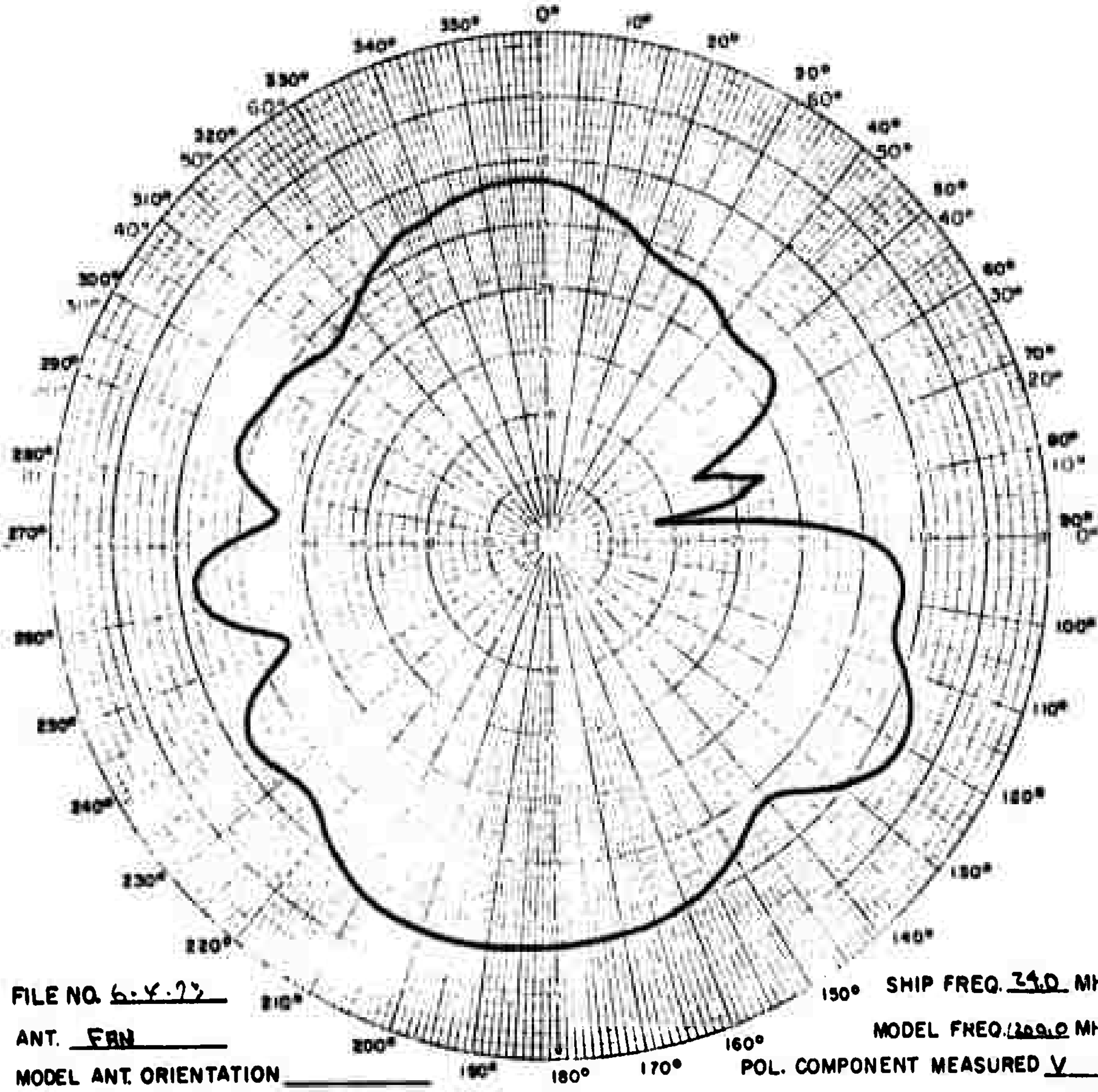
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM / FOLLBORING

ENGR ______ DATE 6-19-73

Figure 24



FILE NO. 6.4.73

ANT. FRN

MODEL ANT. ORIENTATION ______

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 24.0 MHz

MODEL FREQ. 1200.0 MHz

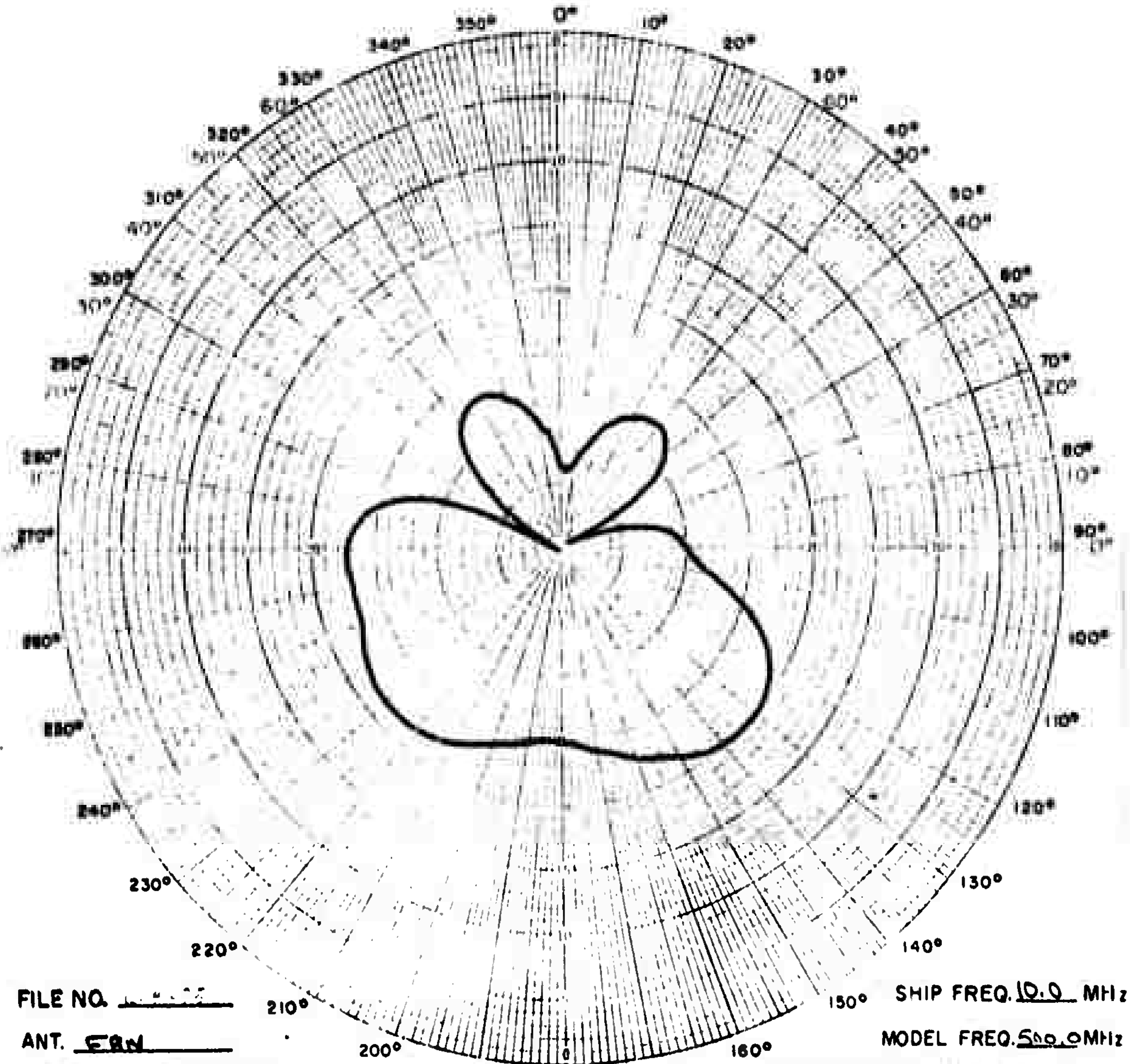
POL. COMPONENT MEASURED V

0 dB ON CHART = 6.0 dB REL. TO λ/4 MONOPOLE

REMARKS PHM/ FOILBORNE

ENGR ______ DATE 6.19.73

Figure 25



FILE NO. ______ SHIP FREQ. 10.0 MHz

ANT. FRN MODEL FREQ. 500.0 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED H

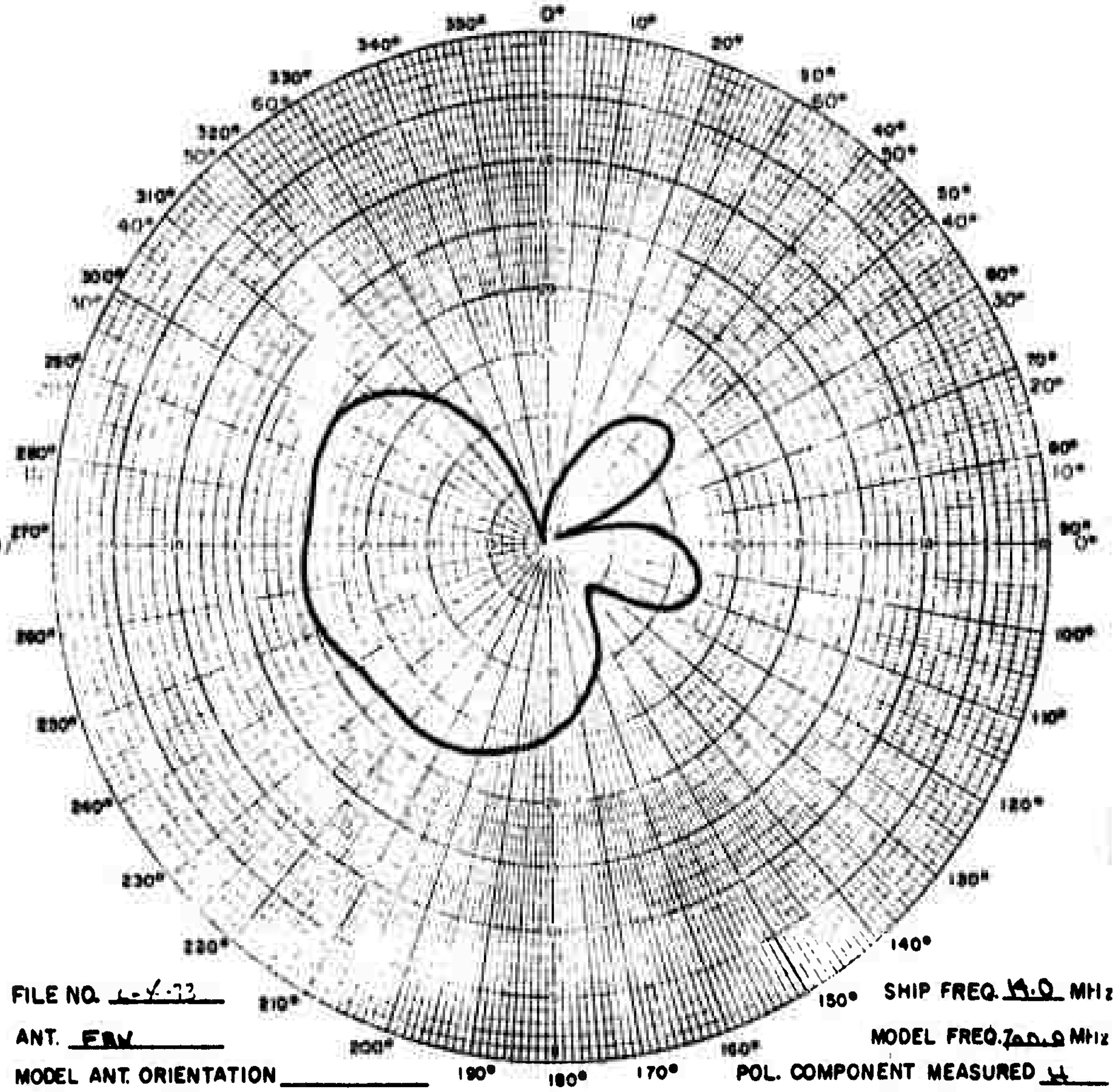
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM / FOILBORNE

ENGR ______ DATE 6-19-73

Figure 26



FILE NO. 6-4-73 SHIP FREQ. 14.0 MHz

ANT. FBW MODEL FREQ. 700.0 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED H

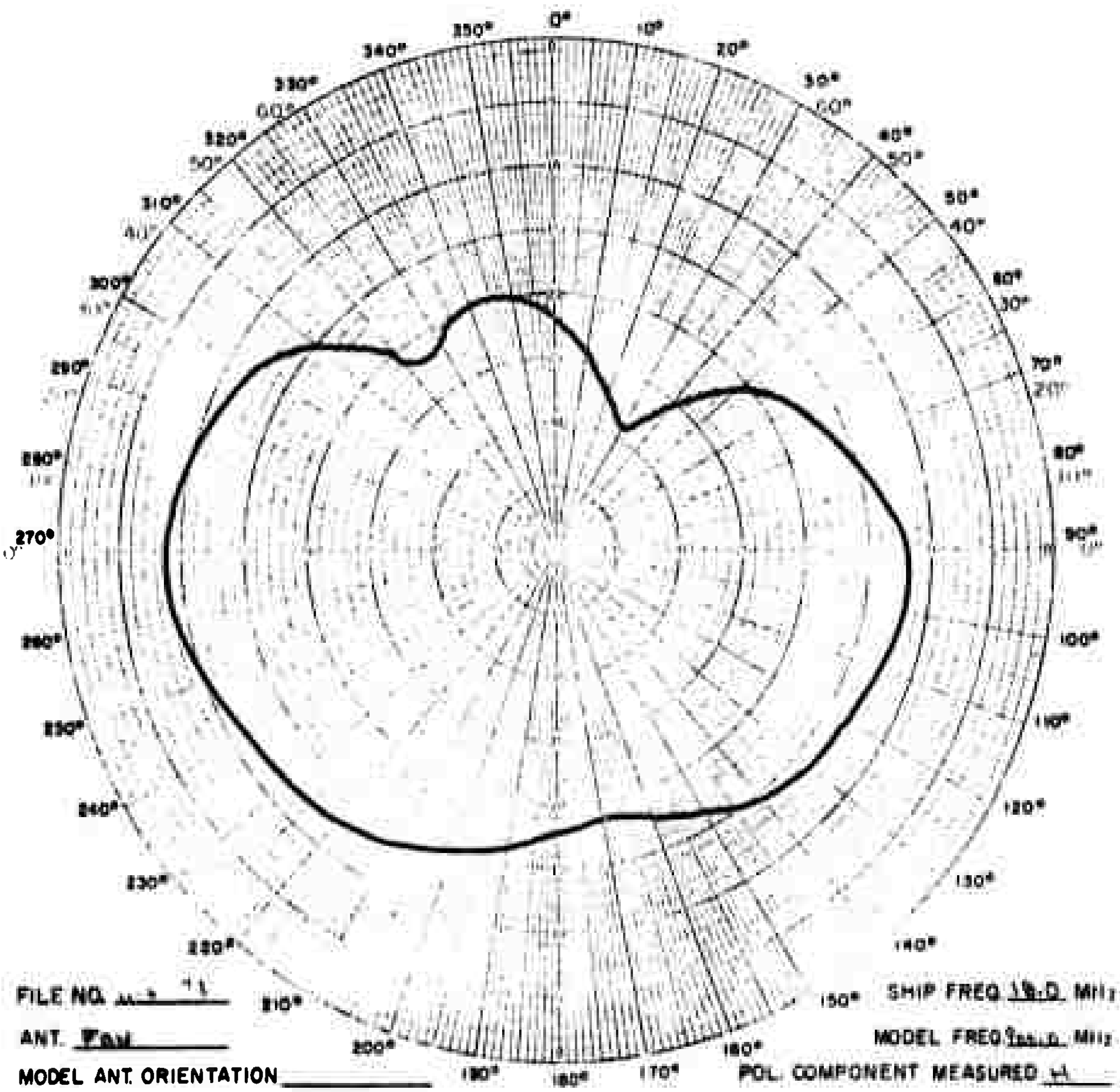
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS FHM / FOILBORNE

ENGR ______ DATE 6-19-73

Figure 27



FILE NO. ______ SHIP FREQ 18.0 MHz

ANT. FAN MODEL FREQ ______ MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED H

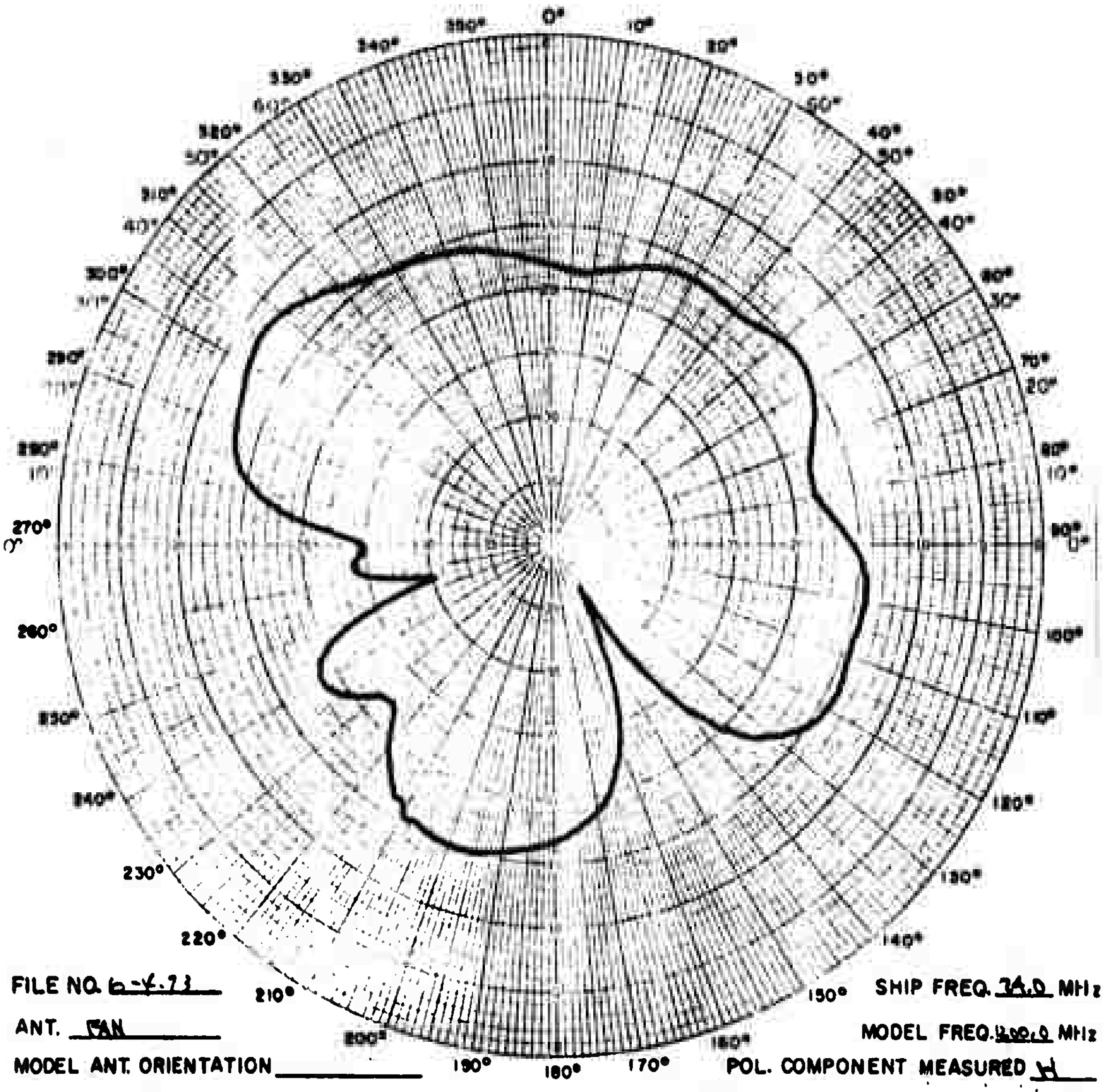
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL.

ELEVATION PATTERN ____ TO ____ DEG. TO λ/4 MONOPOLE

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM / FOILBORNE

ENGR ________ DATE 6-19-73

Figure 28



FILE NO. 6-4-73 SHIP FREQ. 34.0 MHz

ANT. FAN MODEL FREQ. 200.0 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED H

AZIMUTH PATTERN AT 5 DEG. ELEV.

0 dB ON CHART = 0.0 dB REL. TO $\lambda/4$ MONOPOLE

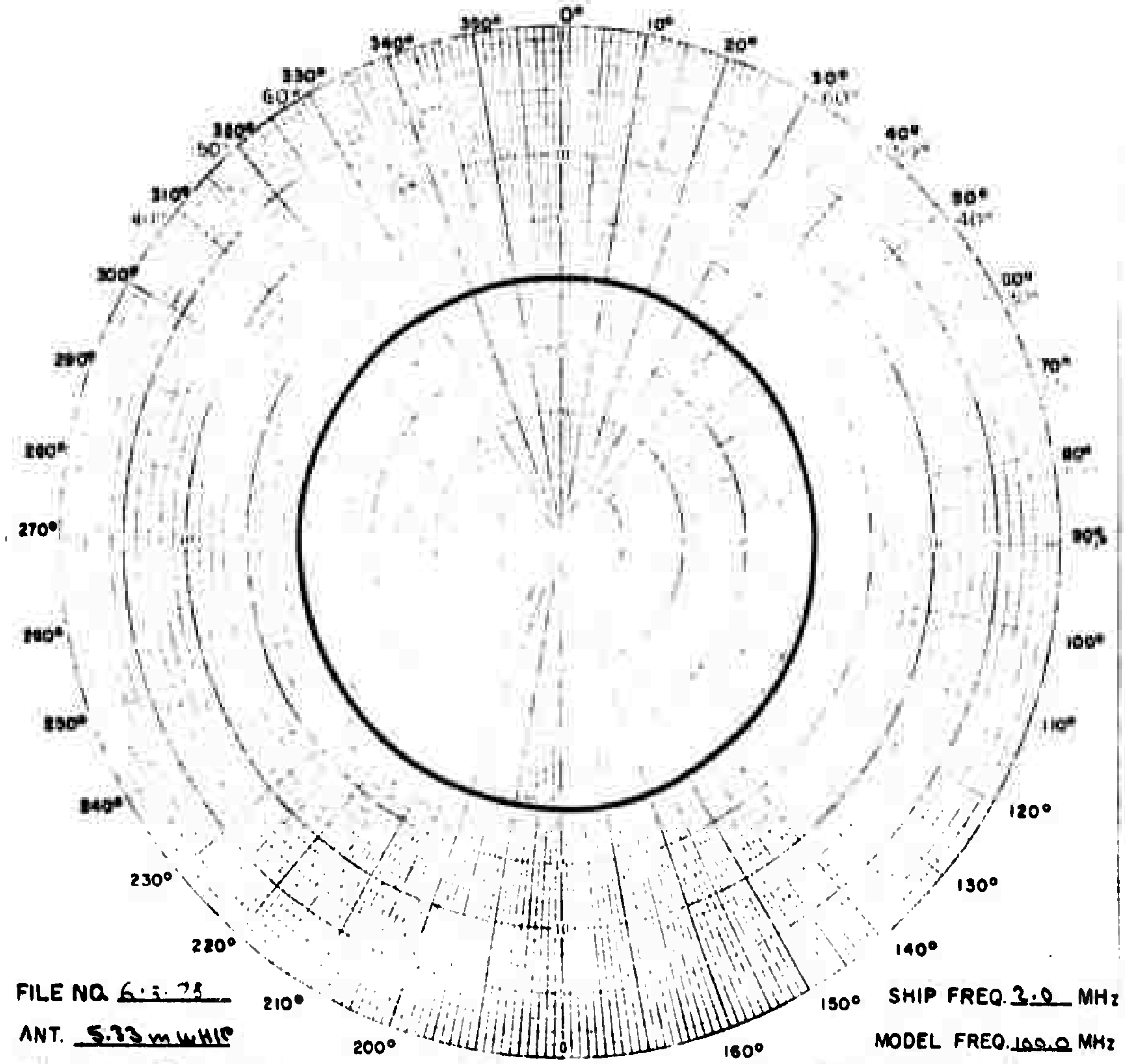
ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

REMARKS PHM / FOILBORNE

ENGR ______ DATE 6-19-73

Figure 29



FILE NO. 6-3-73 SHIP FREQ. 3.0 MHz

ANT. 5.33 m WHIP MODEL FREQ. 100.0 MHz

MODEL ANT. ORIENTATION________ POL. COMPONENT MEASURED V

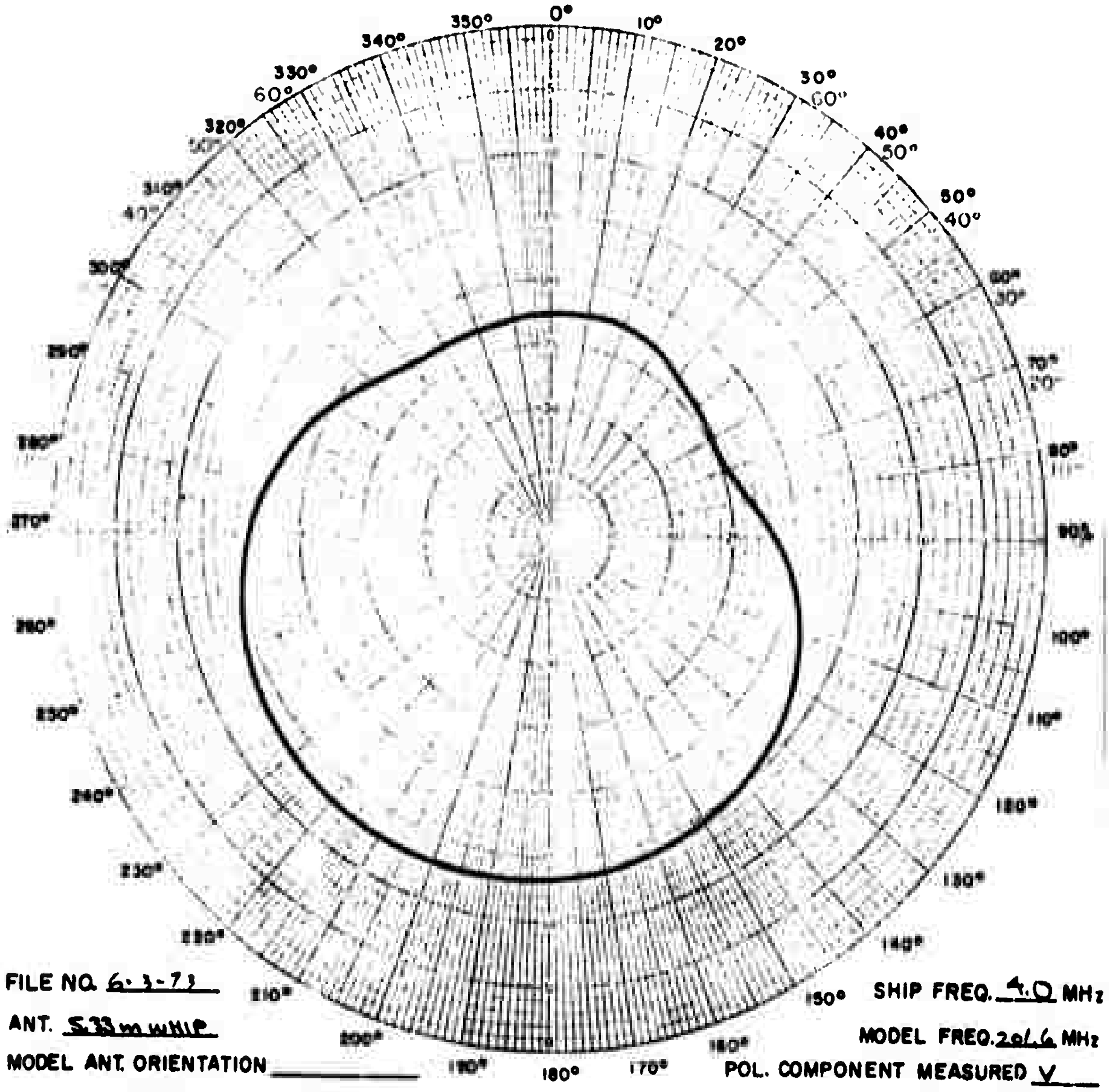
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = -20 dB REL.

ELEVATION PATTERN ____ TO ____ DEG. TO λ/4 MONOPOLE

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS Prim HULLBORNE

ENGR ________ DATE 8 JUNE 73

Figure 30



FILE NO. 6-3-73 SHIP FREQ. 4.0 MHz

ANT. 5.33m WHIP MODEL FREQ. 206.6 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED V

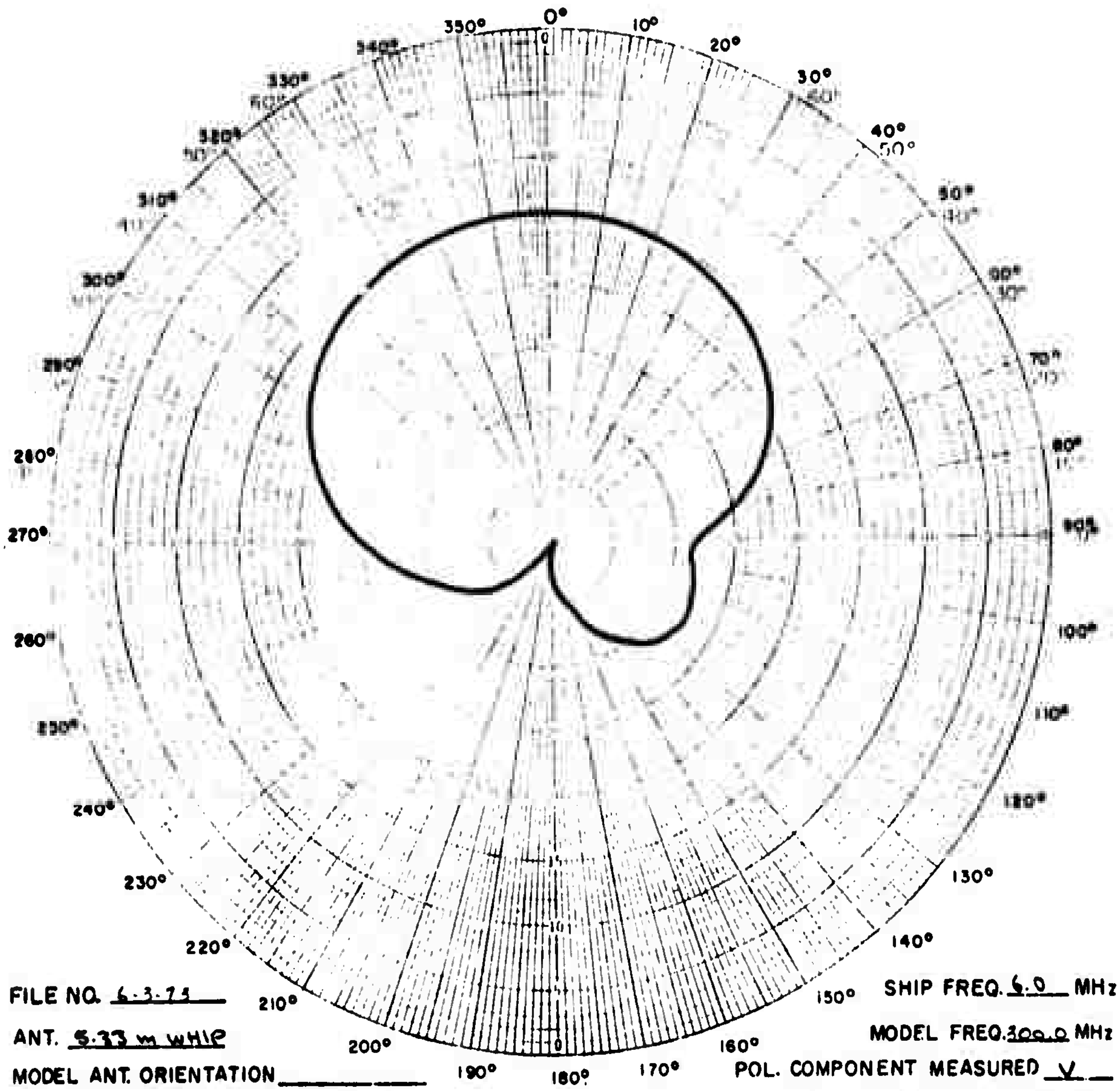
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = -10 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM HULLBORNE

ENGR ______ DATE 1 June 73

Figure 31



FILE NO. 6-3-73 SHIP FREQ. 6.0 MHz

ANT. 5.33 m WHIP MODEL FREQ. 300.0 MHz

MODEL ANT. ORIENTATION ____ POL. COMPONENT MEASURED V

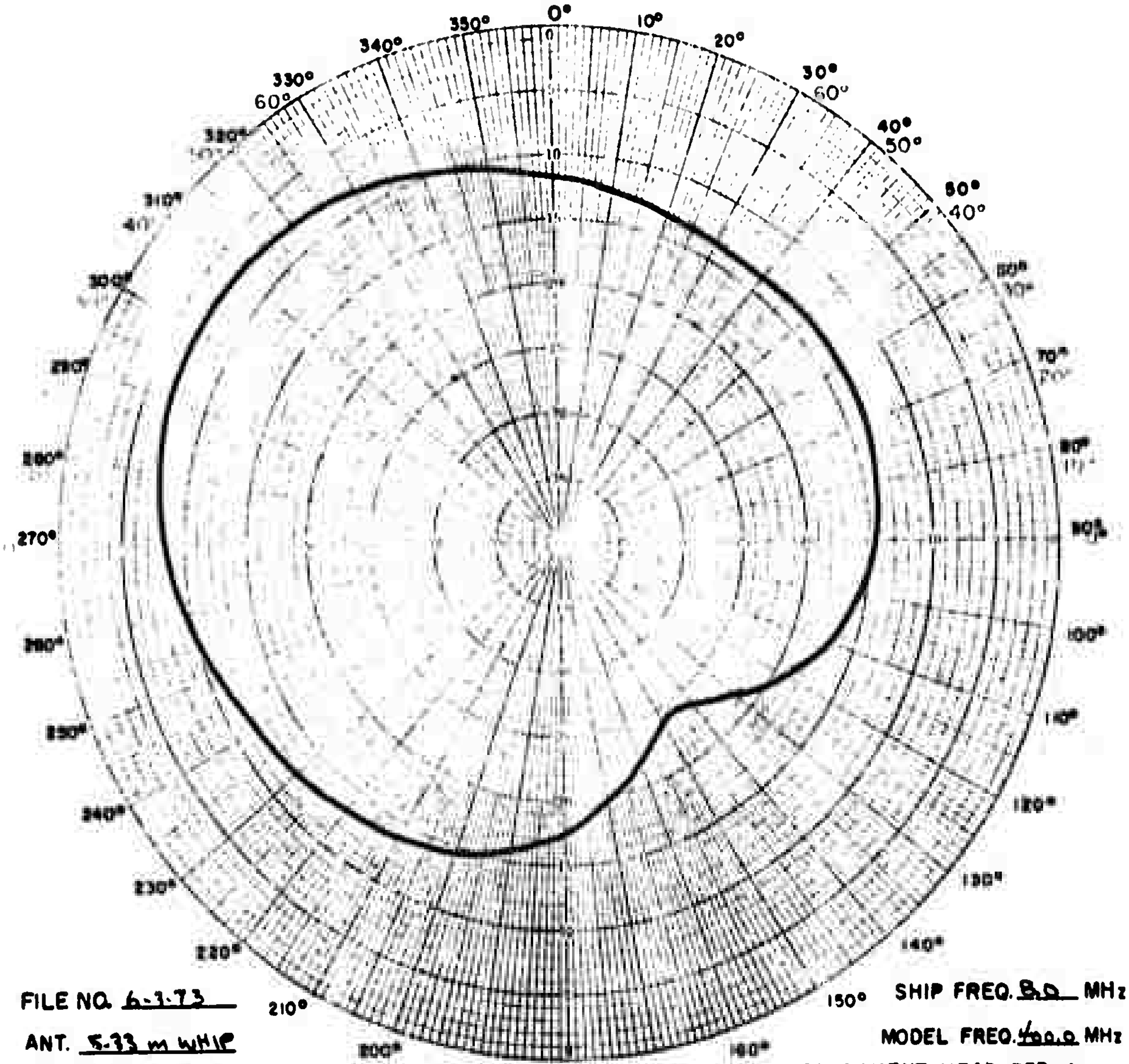
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM HULLBORNE

ENGR ____ DATE 8 June 73

Figure 32



FILE NO. 6-3-73

ANT. 5.33 m WHIP

MODEL ANT. ORIENTATION ________

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 8.0 MHz

MODEL FREQ. 400.0 MHz

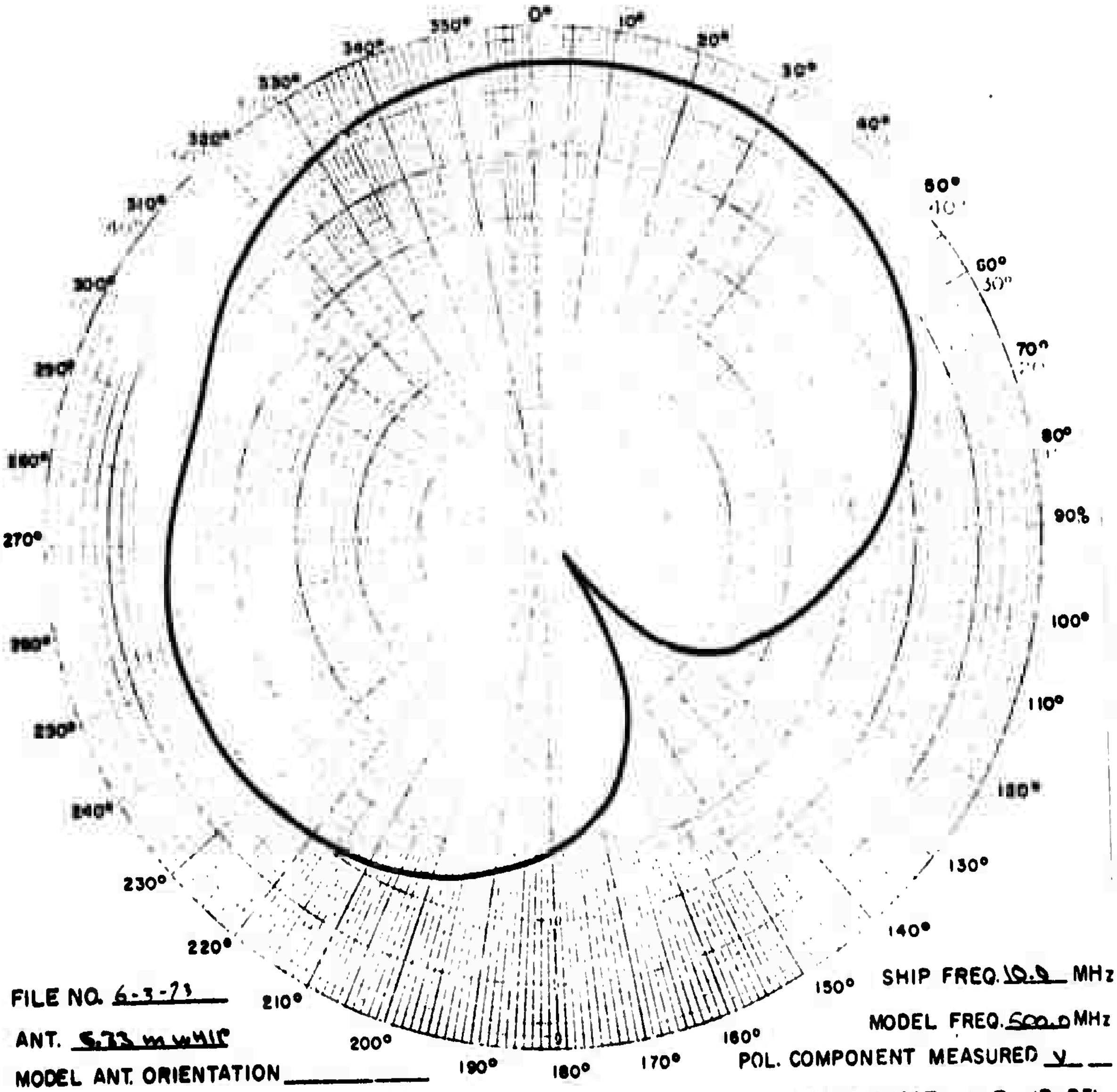
POL. COMPONENT MEASURED V

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS PHM HULLBORNE

ENGR ________ DATE 9 JUNE 73

Figure 33



FILE NO. 6-3-73

ANT. 5.33 m WHIP

MODEL ANT. ORIENTATION ________

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 10.0 MHz

MODEL FREQ. 500.0 MHz

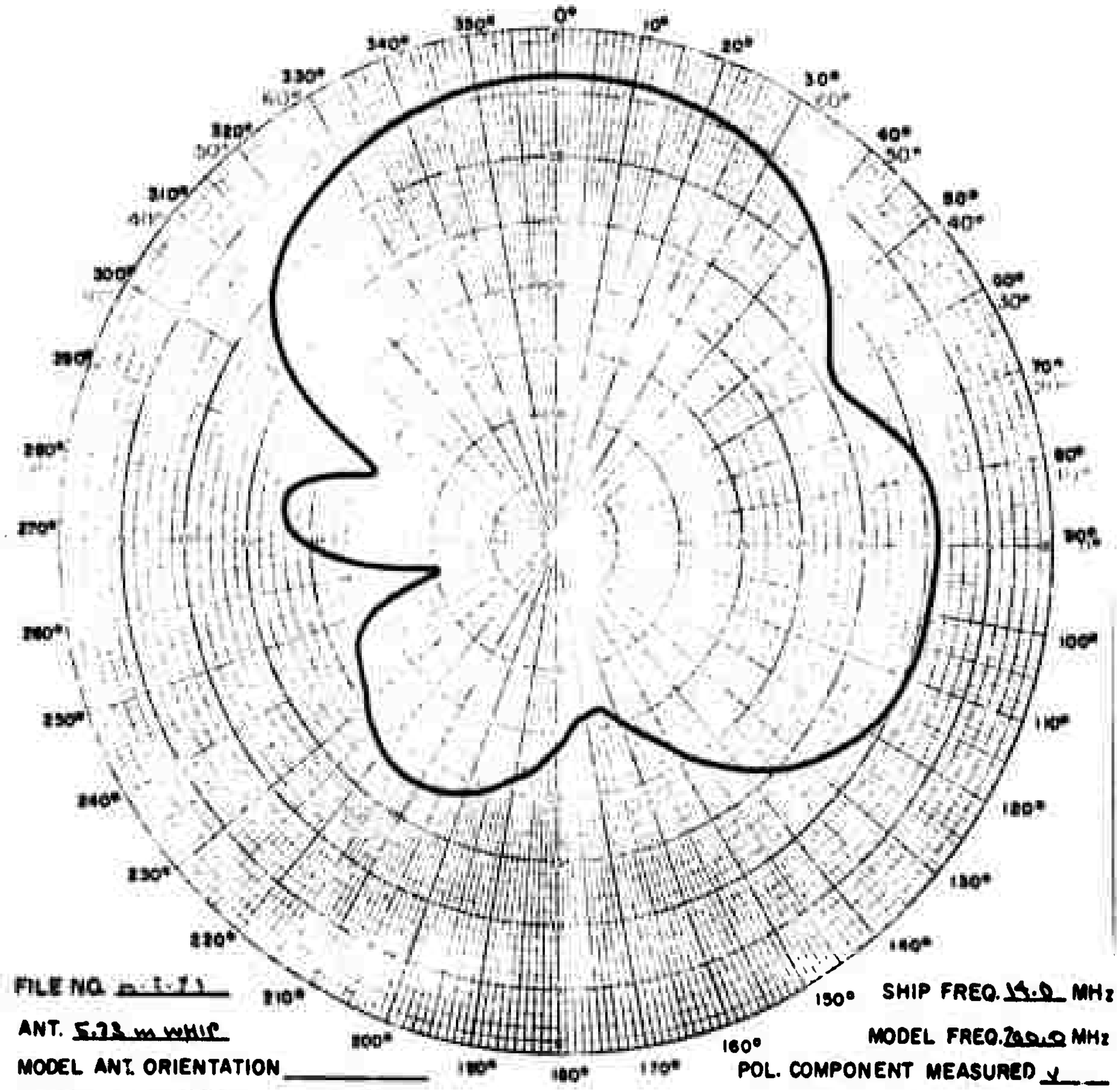
POL. COMPONENT MEASURED V

0 dB ON CHART = ±5 dB REL. TO λ/4 MONOPOLE

REMARKS PHM HULLBORNE

ENGR ________ DATE 9 June 73

Figure 34



FILE NO. A-1-73

ANT. 5.73 m WHIP

MODEL ANT. ORIENTATION ______

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 14.0 MHz

MODEL FREQ. 280.0 MHz

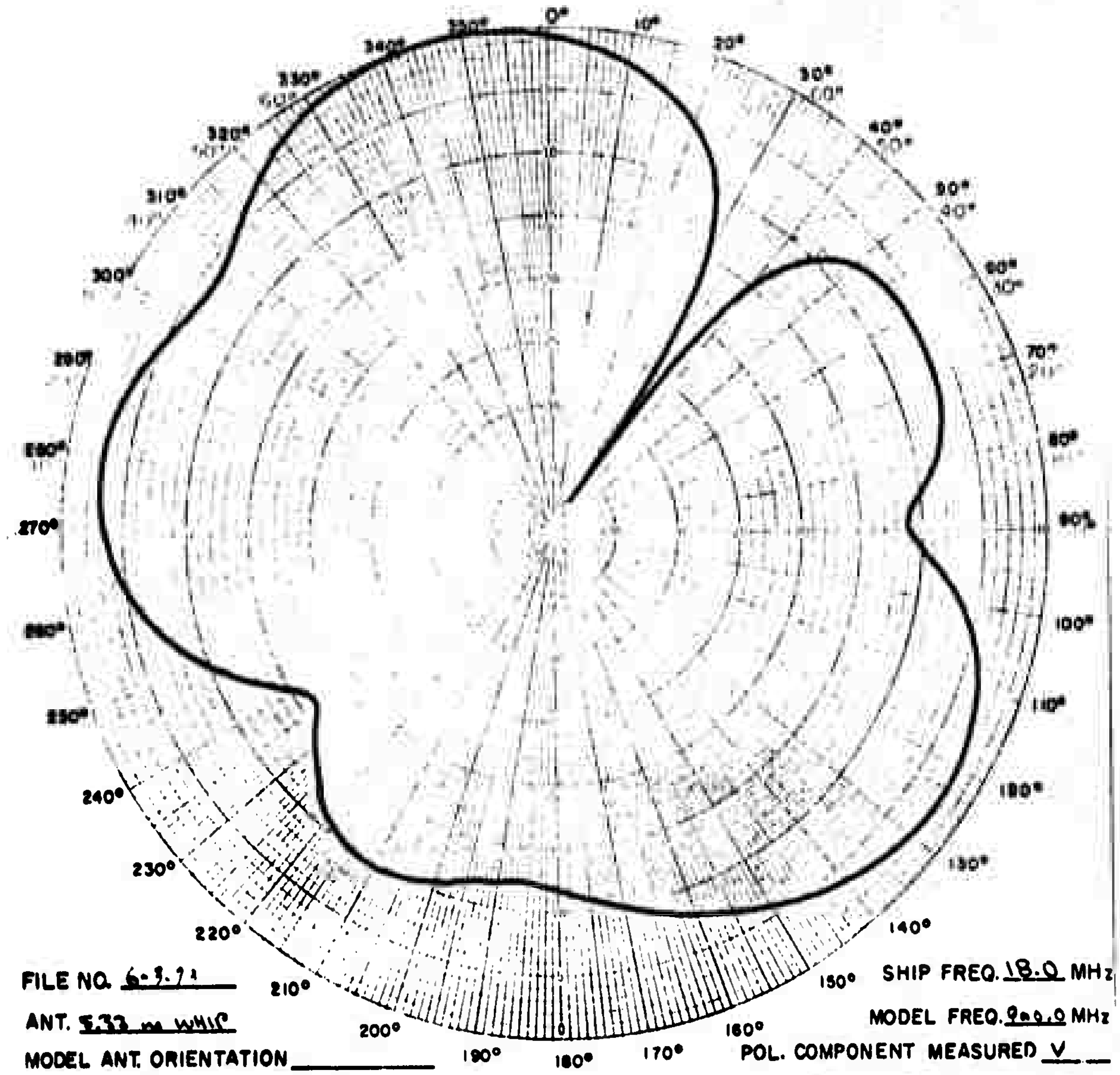
POL. COMPONENT MEASURED V

0 dB ON CHART = +10 dB REL. TO λ/4 MONOPOLE

REMARKS PHM HULLBORNE

ENGR ______ DATE 8 JUNE 73

Figure 35



FILE NO. 6-3-71

ANT. 5.33 m WHIP

MODEL ANT. ORIENTATION ________

AZIMUTH PATTERN AT 6 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 18.0 MHz

MODEL FREQ. 900.0 MHz

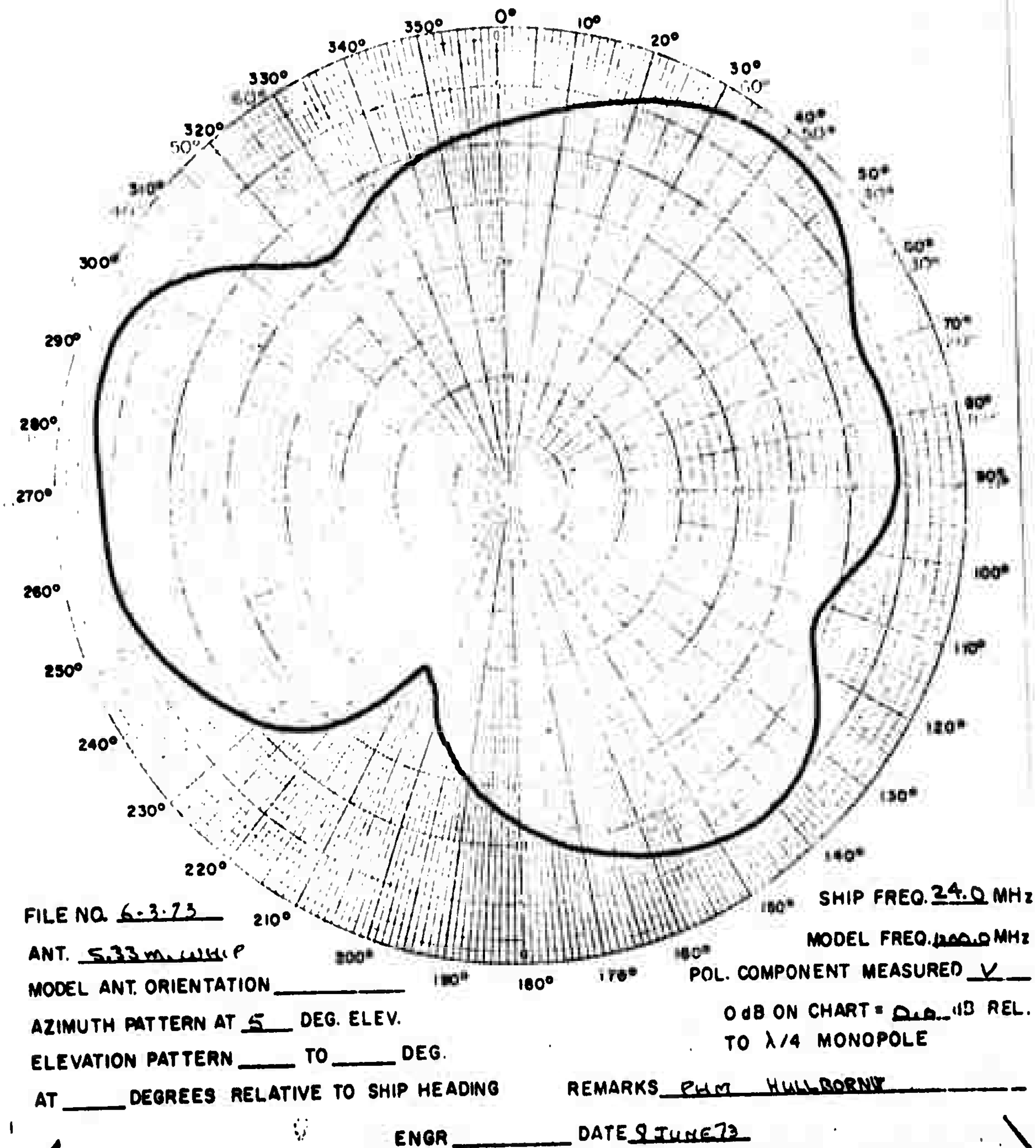
POL. COMPONENT MEASURED V

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

REMARKS PHM HULLBORNE

ENGR ________ DATE 9 JUNE 71

Figure 36


0°
10°
20°
30°
40°
50°
60°
70°
80°
90°
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110°
120°
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140°
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170°
180°
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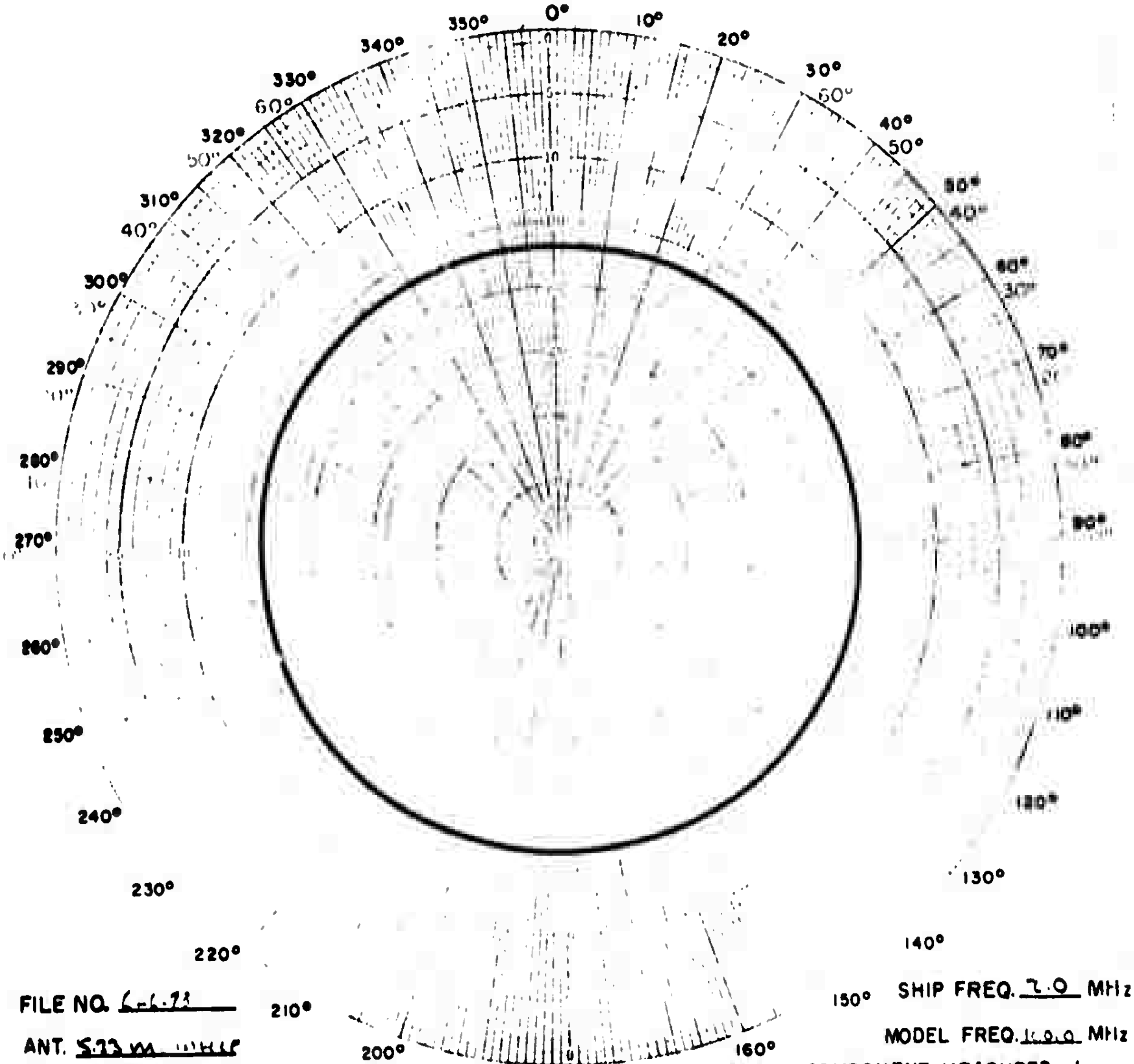
210°
220°
230°
240°
250°
260°
270°
280°
290°
300°
310°
320°
330°
340°
350°
FILE NO. 6-3-73
ANT. 5.33m. WHIP
MODEL ANT. ORIENTATION
AZIMUTH PATTERN AT 5 DEG. ELEV.
ELEVATION PATTERN TO DEG.
AT DEGREES RELATIVE TO SHIP HEADING
SHIP FREQ. 24.0 MHz
MODEL FREQ. MHz
POL. COMPONENT MEASURED V
0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE
REMARKS PHM HULLBORNE
ENGR
DATE 9 JUNE 73

Figure 37



FILE NO. 6-6-73

ANT. 5.33 m WHIP

MODEL ANT. ORIENTATION ________

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 2.0 MHz

MODEL FREQ. 100.0 MHz

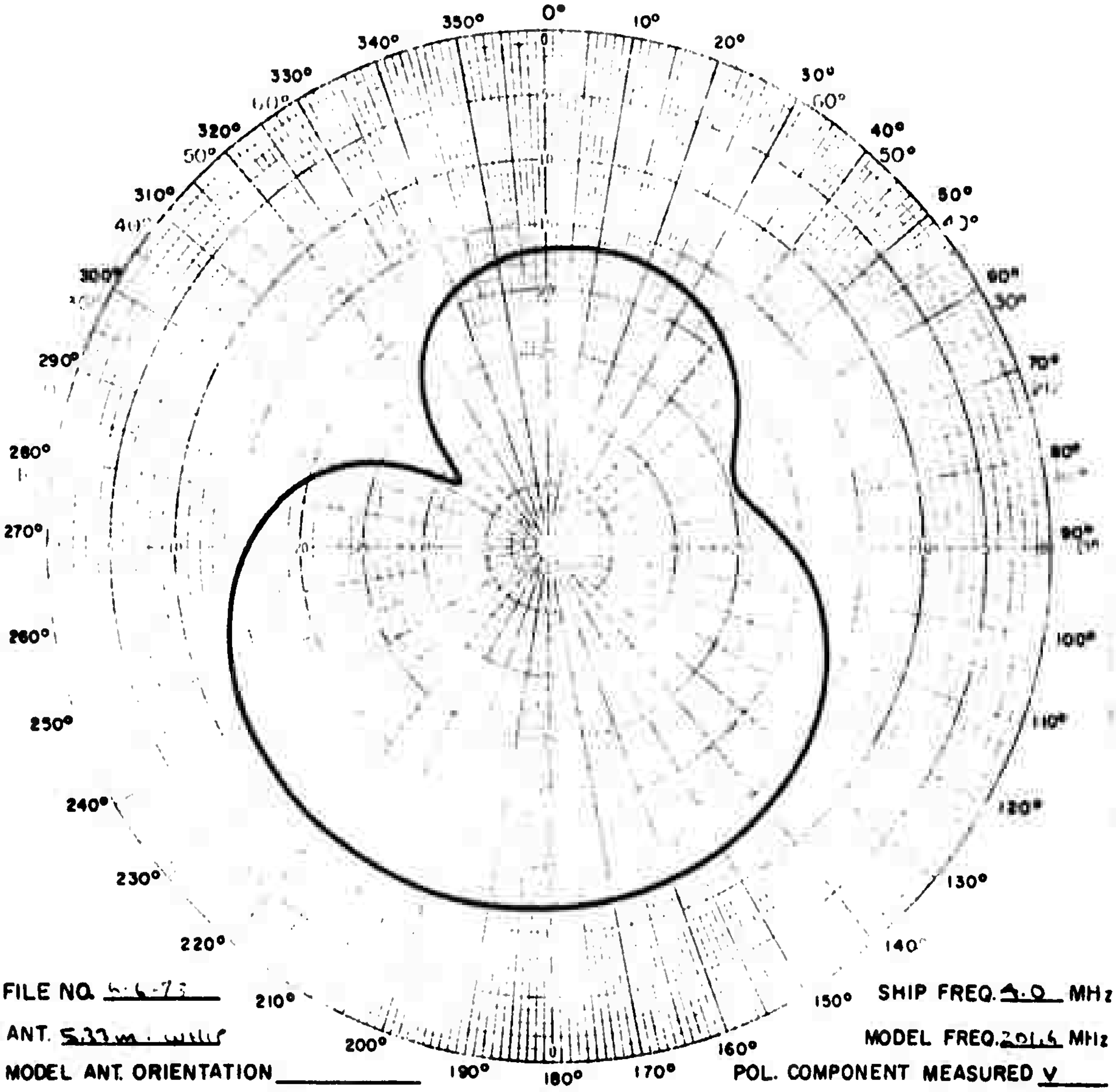
POL. COMPONENT MEASURED V

0 dB ON CHART = -20 dB REL. TO λ/4 MONOPOLE

REMARKS PHM/HYDRO. FOILBORNE

ENGR ________ DATE 20 JUNE 73

Figure 38



FILE NO. 6-6-73 SHIP FREQ. 4.0 MHz

ANT. 5.33m whip MODEL FREQ. 201.6 MHz

MODEL ANT. ORIENTATION ____ POL. COMPONENT MEASURED V

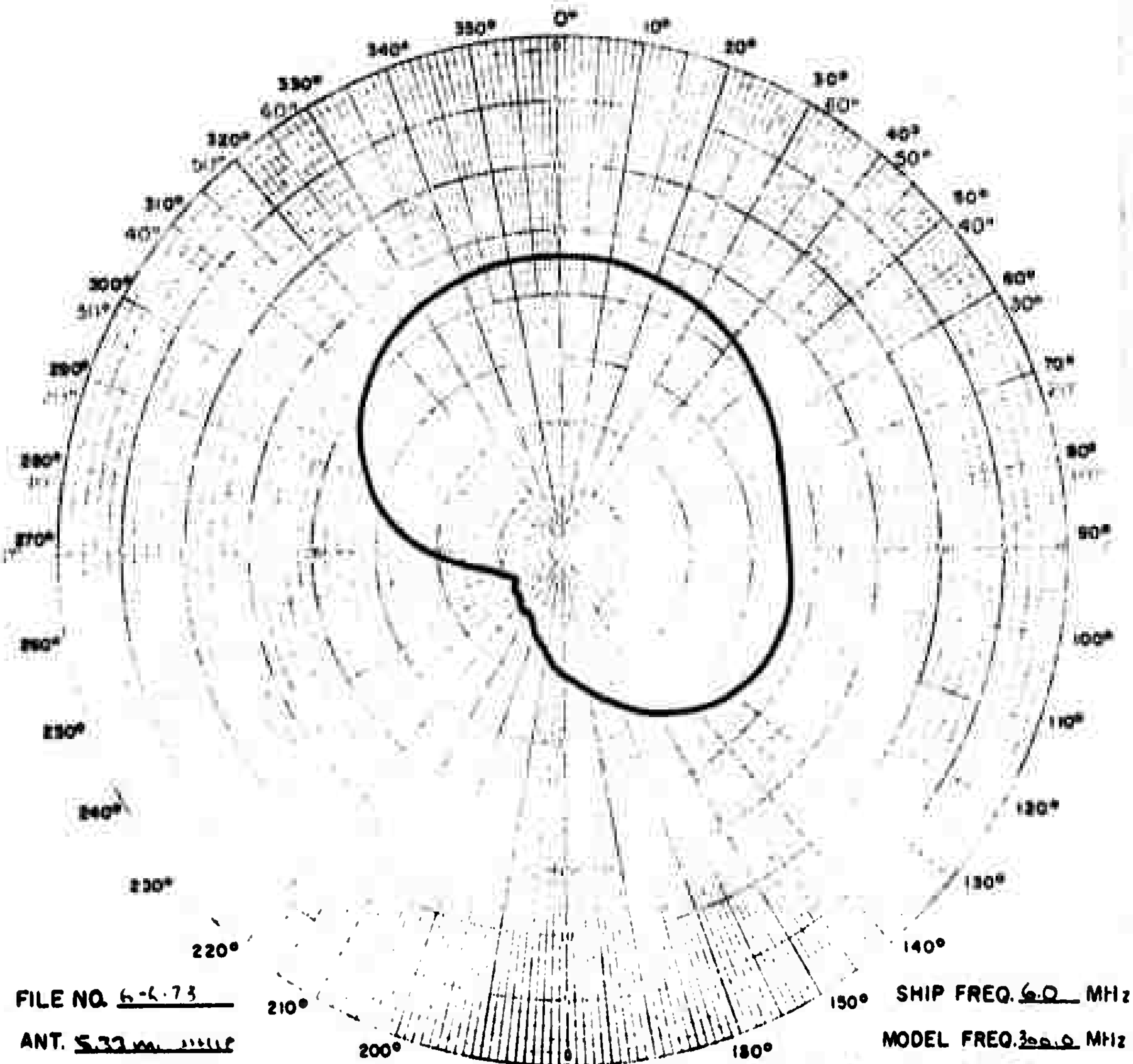
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = -10 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM / HYDRO. FOILBORNE

ENGR ____ DATE 20 JUNE 73

Figure 39



FILE NO. 6-6-73 SHIP FREQ. 6.0 MHz

ANT. MODEL FREQ. 300.0 MHz

MODEL ANT. ORIENTATION ________ POL. COMPONENT MEASURED V

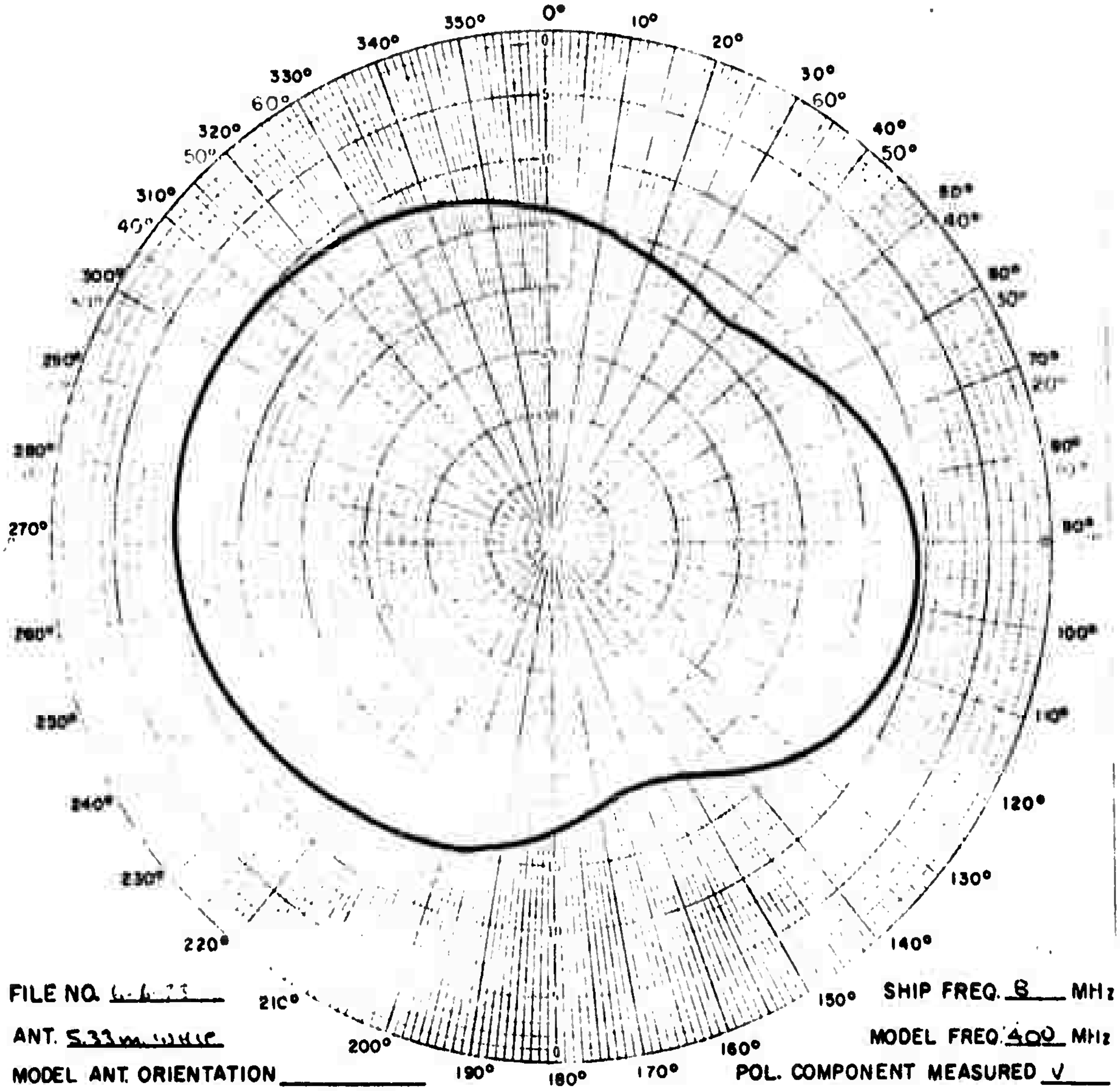
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS

ENGR ________ DATE

Figure 40



FILE NO. 6-6-73 SHIP FREQ. 8 MHz

ANT. 5.33m whip MODEL FREQ. 400 MHz

MODEL ANT. ORIENTATION ______ POL. COMPONENT MEASURED V

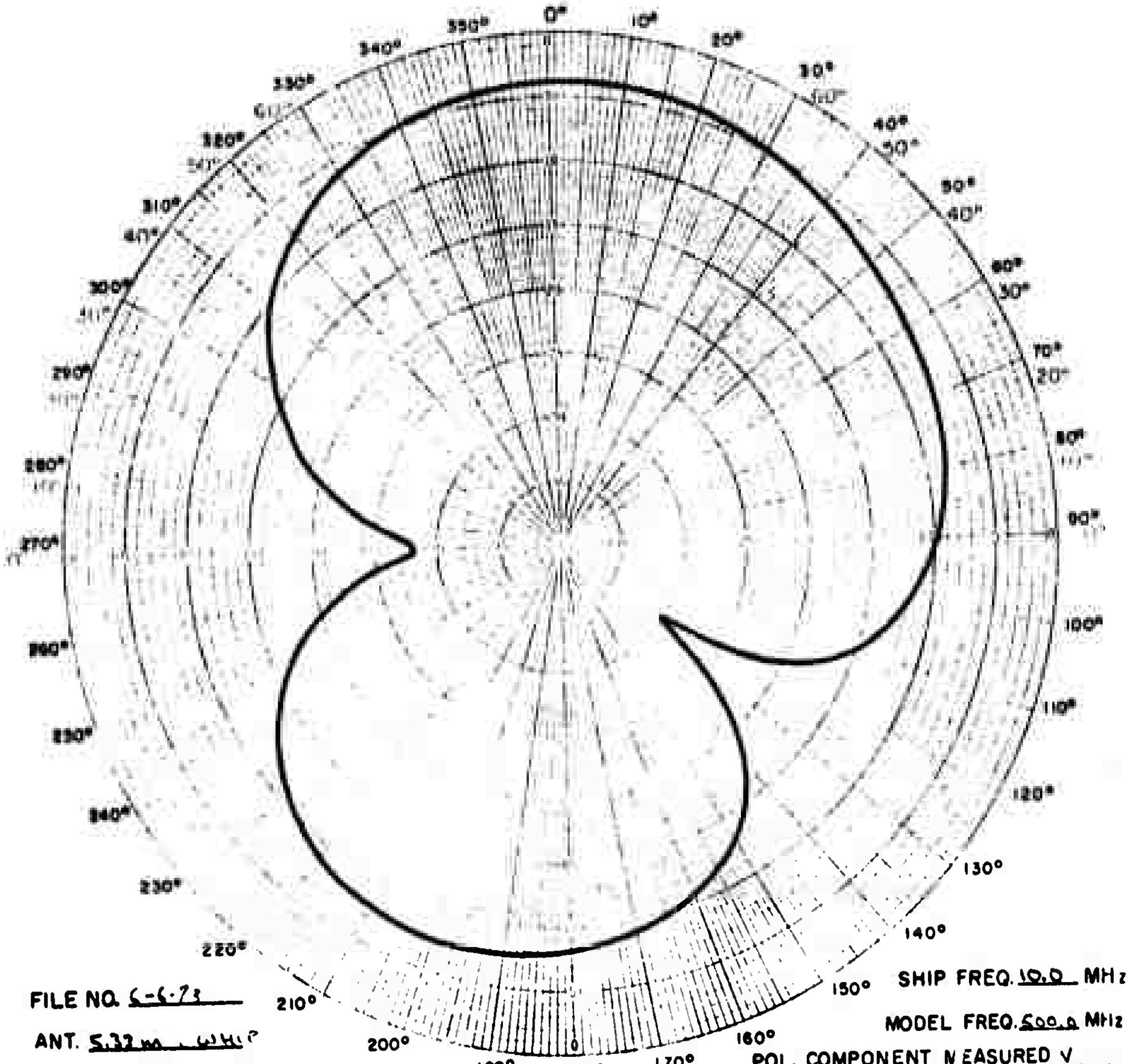
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM/HYDRO. FOILBORNE

ENGR ________ DATE 20 JUNE 73

Figure 41



FILE NO. 6-6-73

ANT. 5.33 m. WHIP

MODEL ANT. ORIENTATION ____________

AZIMUTH PATTERN AT 5 DEG. ELEV.

ELEVATION PATTERN _____ TO _____ DEG.

AT _____ DEGREES RELATIVE TO SHIP HEADING

SHIP FREQ. 10.0 MHz

MODEL FREQ. 500.0 MHz

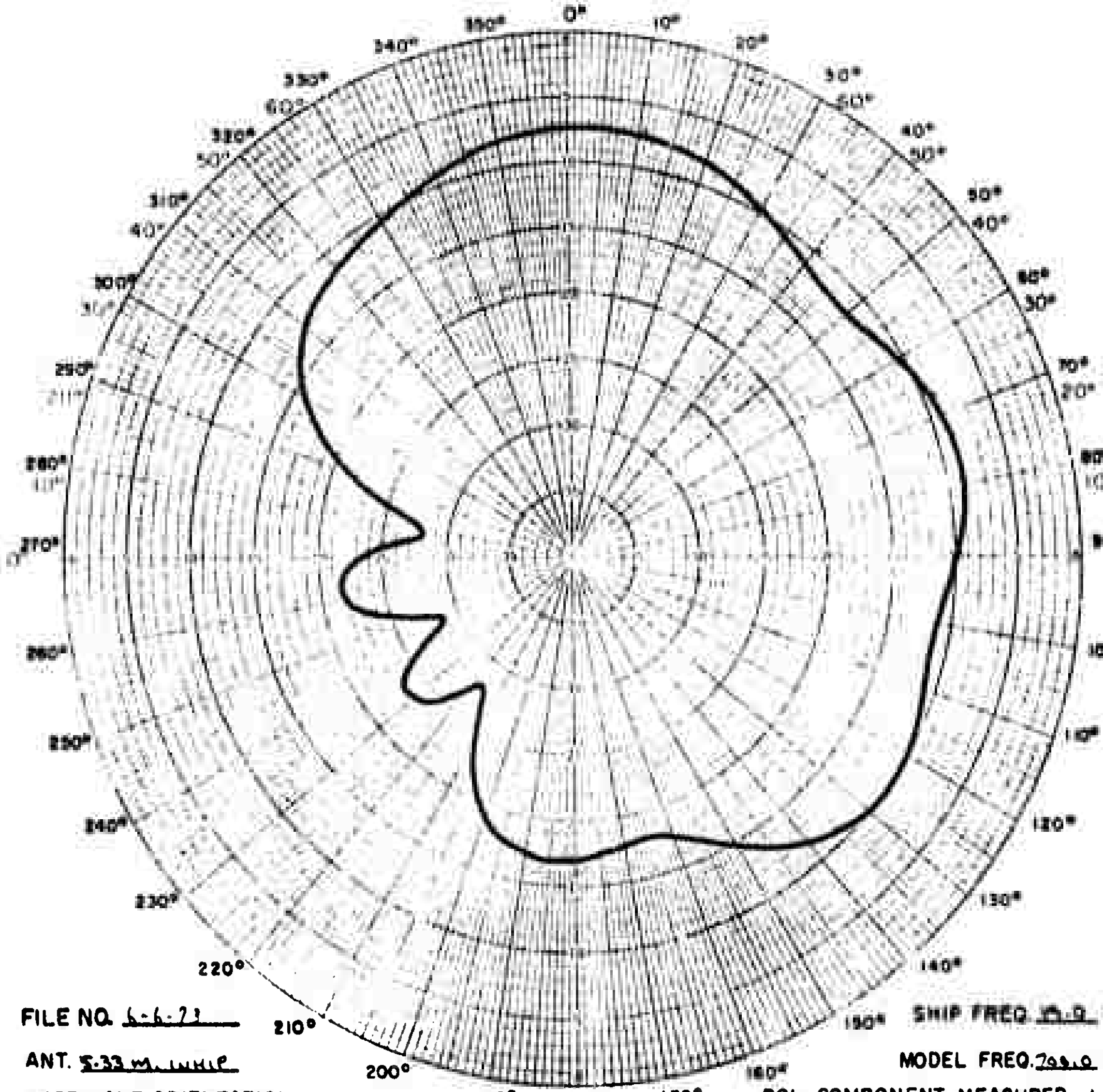
POL. COMPONENT MEASURED V

0 dB ON CHART = +5 dB REL. TO λ/4 MONOPOLE

REMARKS HHM/HYDRO. FOILBORNE

ENGR ________ DATE 20 June 73

Figure 42



FILE NO. 6-6-73 SHIP FREQ 15.0 MHz

ANT. 5.33 M. WHIP MODEL FREQ. 705.0 MHz

MODEL ANT. ORIENTATION ________ POL. COMPONENT MEASURED V

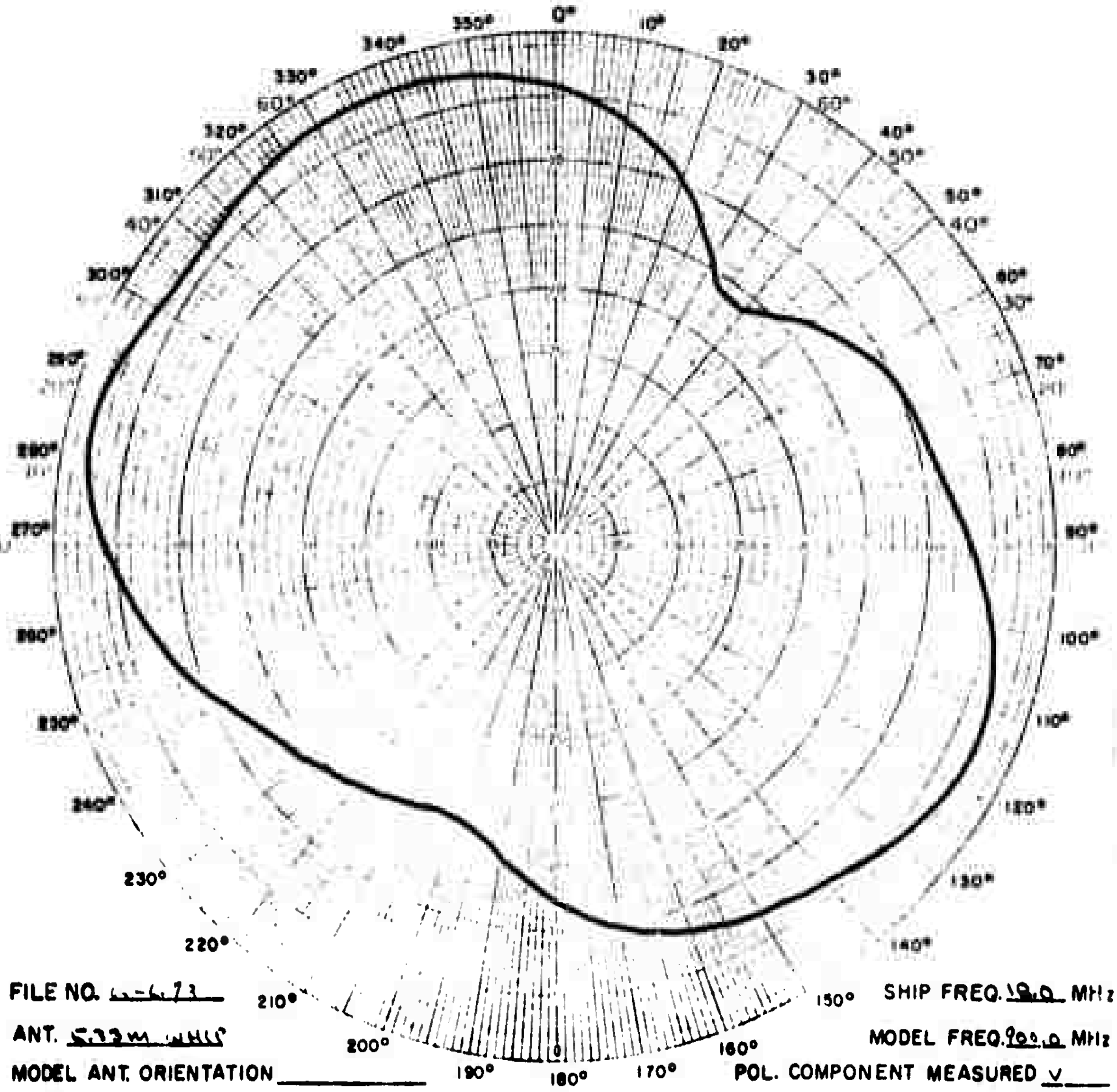
AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = +10 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM/HYDRO. FOILBORNE

ENGR ________ DATE 20 JUNE 73

Figure 43



FILE NO. 6-6-73

SHIP FREQ. 19.0 MHz

ANT. 533M WHIP

MODEL FREQ. 900.0 MHz

MODEL ANT. ORIENTATION ______

POL. COMPONENT MEASURED V

AZIMUTH PATTERN AT 5 DEG. ELEV.

0 dB ON CHART = 0.0 dB REL. TO λ/4 MONOPOLE

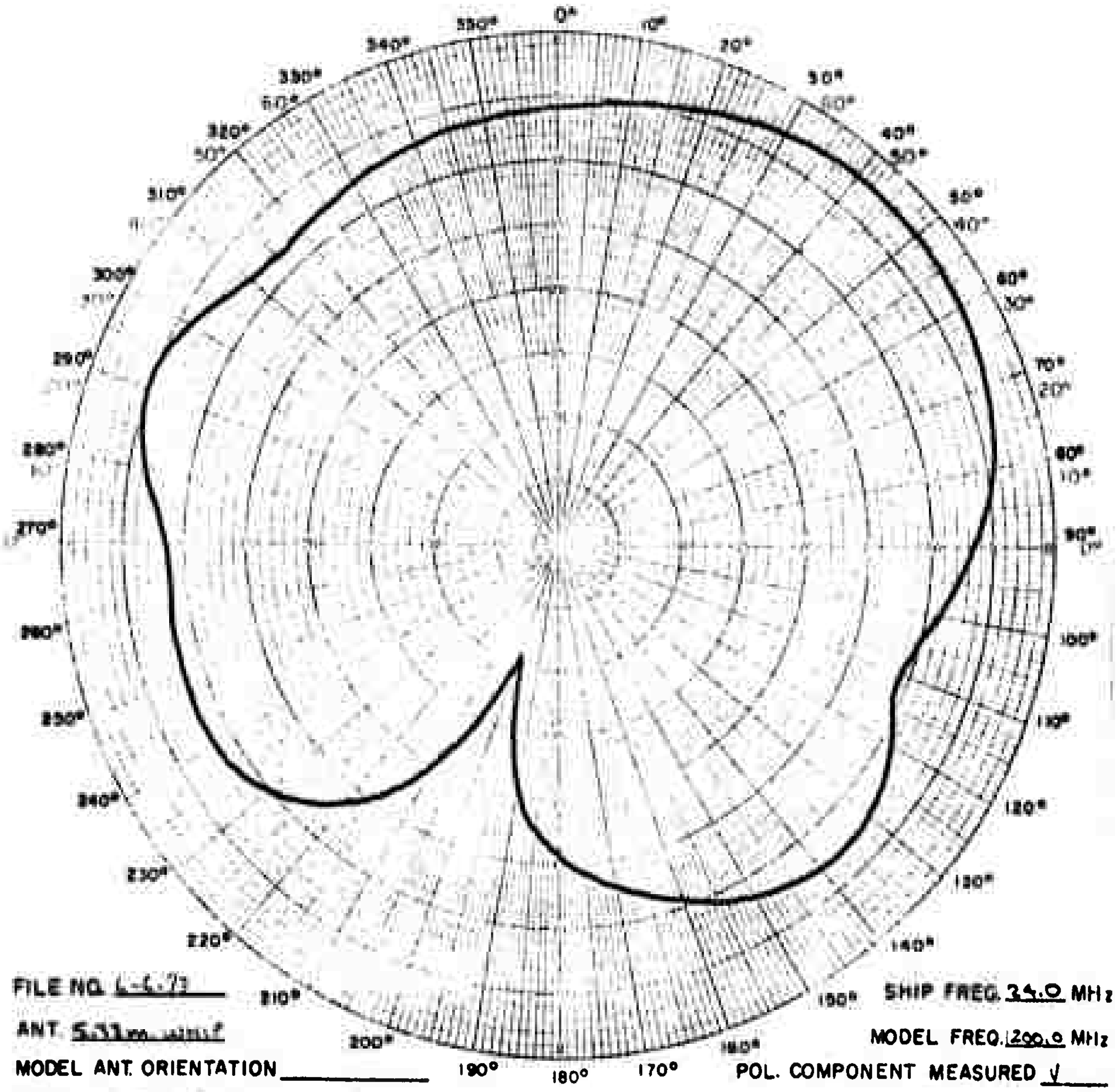
ELEVATION PATTERN ____ TO ____ DEG.

AT ____ DEGREES RELATIVE TO SHIP HEADING

REMARKS PHM / HYDRO FOILBORNE

ENGR ______ DATE 20 JUNE 73

Figure 44



FILE NO. 6-6-73 SHIP FREQ. 34.0 MHz

ANT. 5.33m whip MODEL FREQ. 1200.0 MHz

MODEL ANT. ORIENTATION ____________ POL. COMPONENT MEASURED V

AZIMUTH PATTERN AT 5 DEG. ELEV. 0 dB ON CHART = 6.0 dB REL. TO λ/4 MONOPOLE

ELEVATION PATTERN _____ TO ______ DEG.

AT ______ DEGREES RELATIVE TO SHIP HEADING REMARKS PHM/HYDRO. FOILBORNE

ENGR __________ DATE 20 JUNE 73

Figure 45

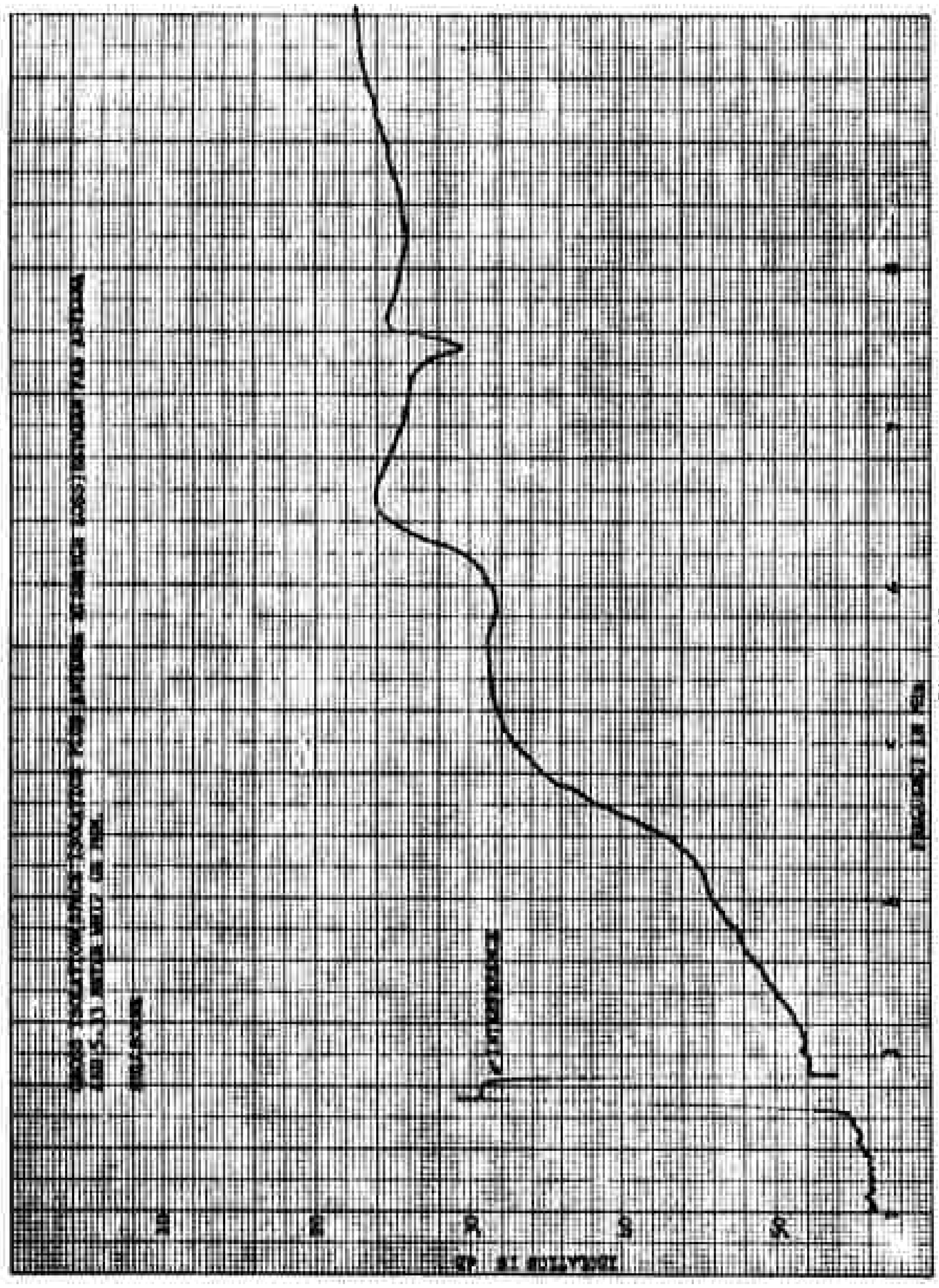


Figure 46

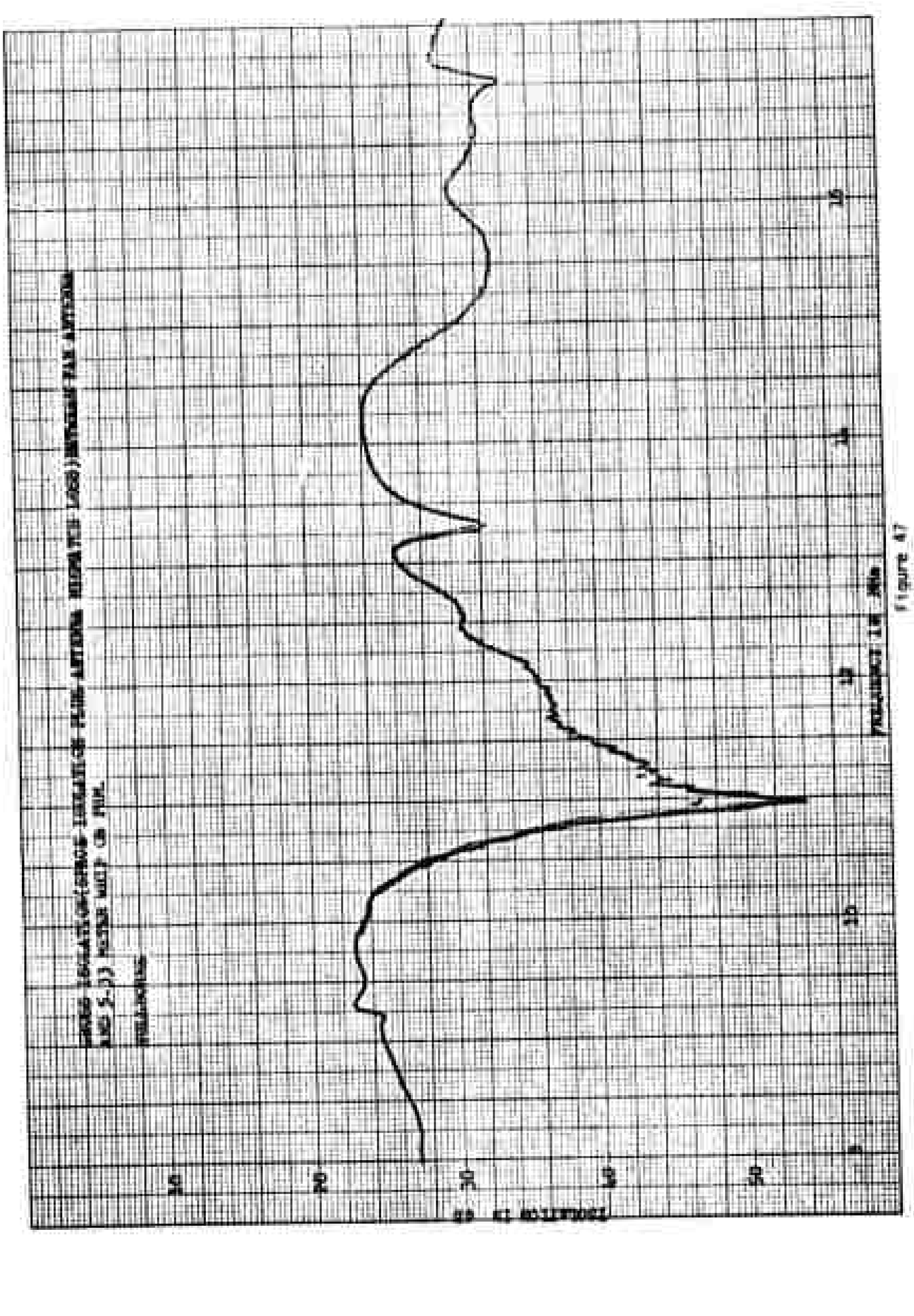


Figure 47

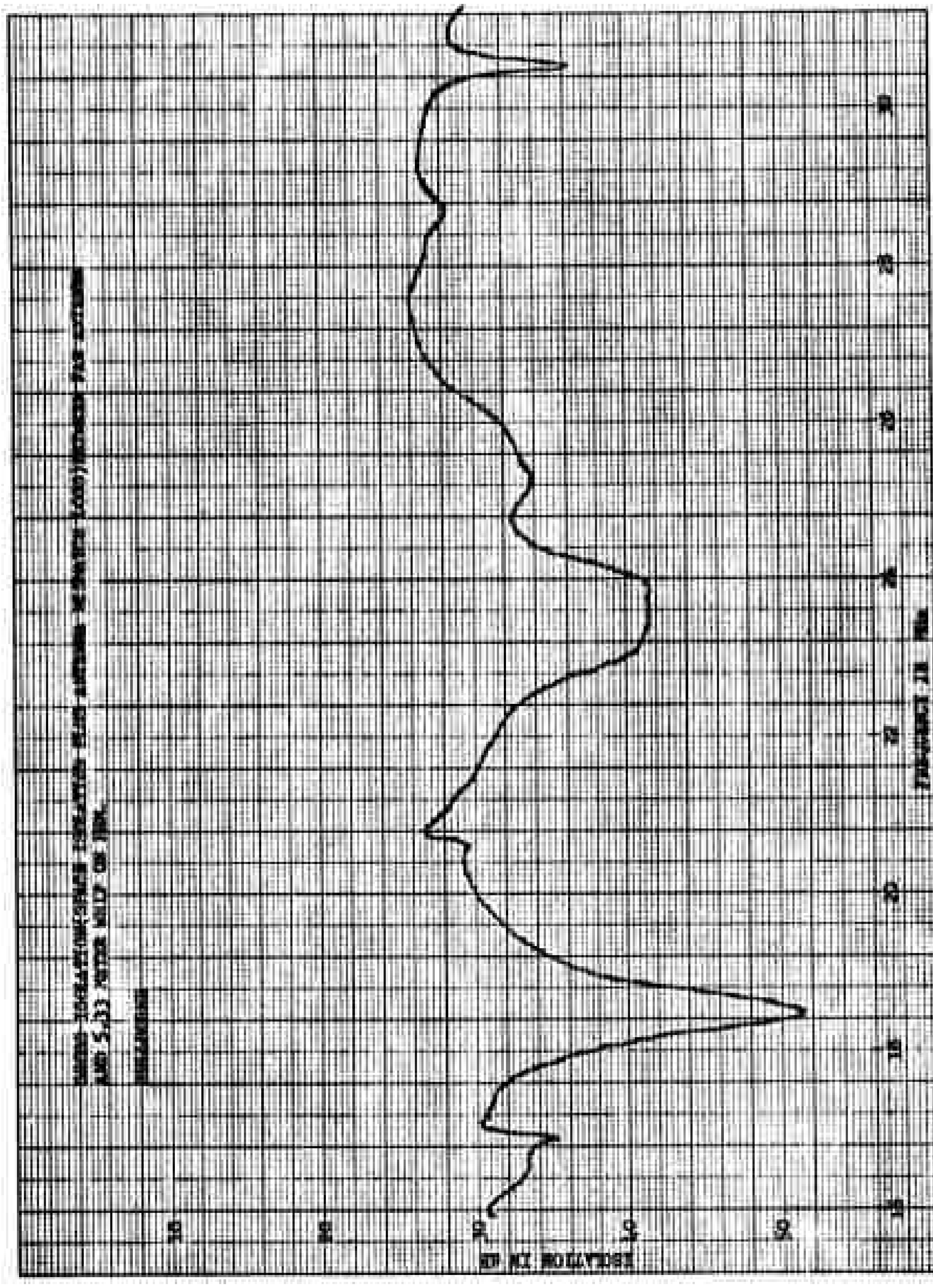


Figure 48

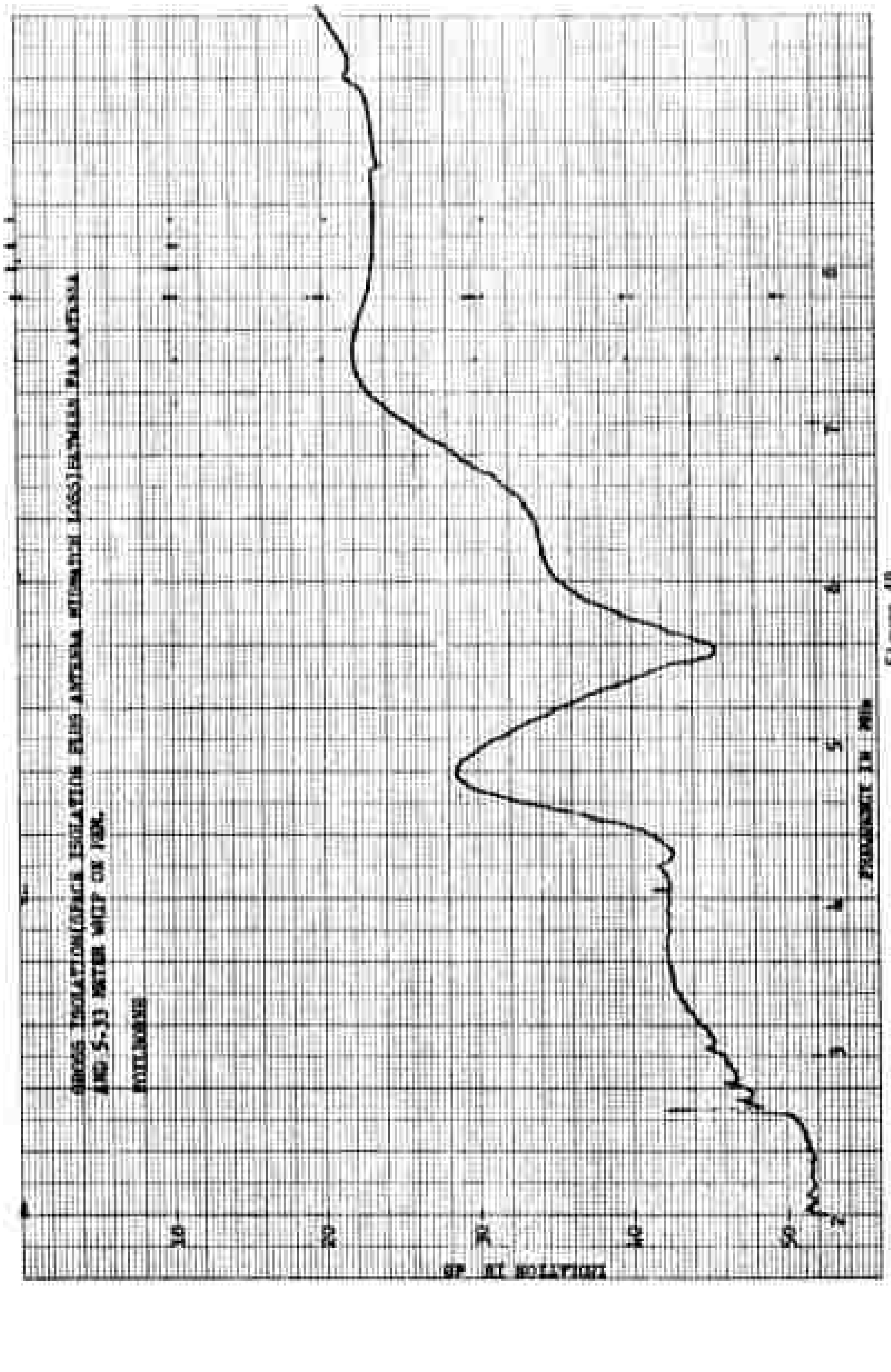


Figure 49

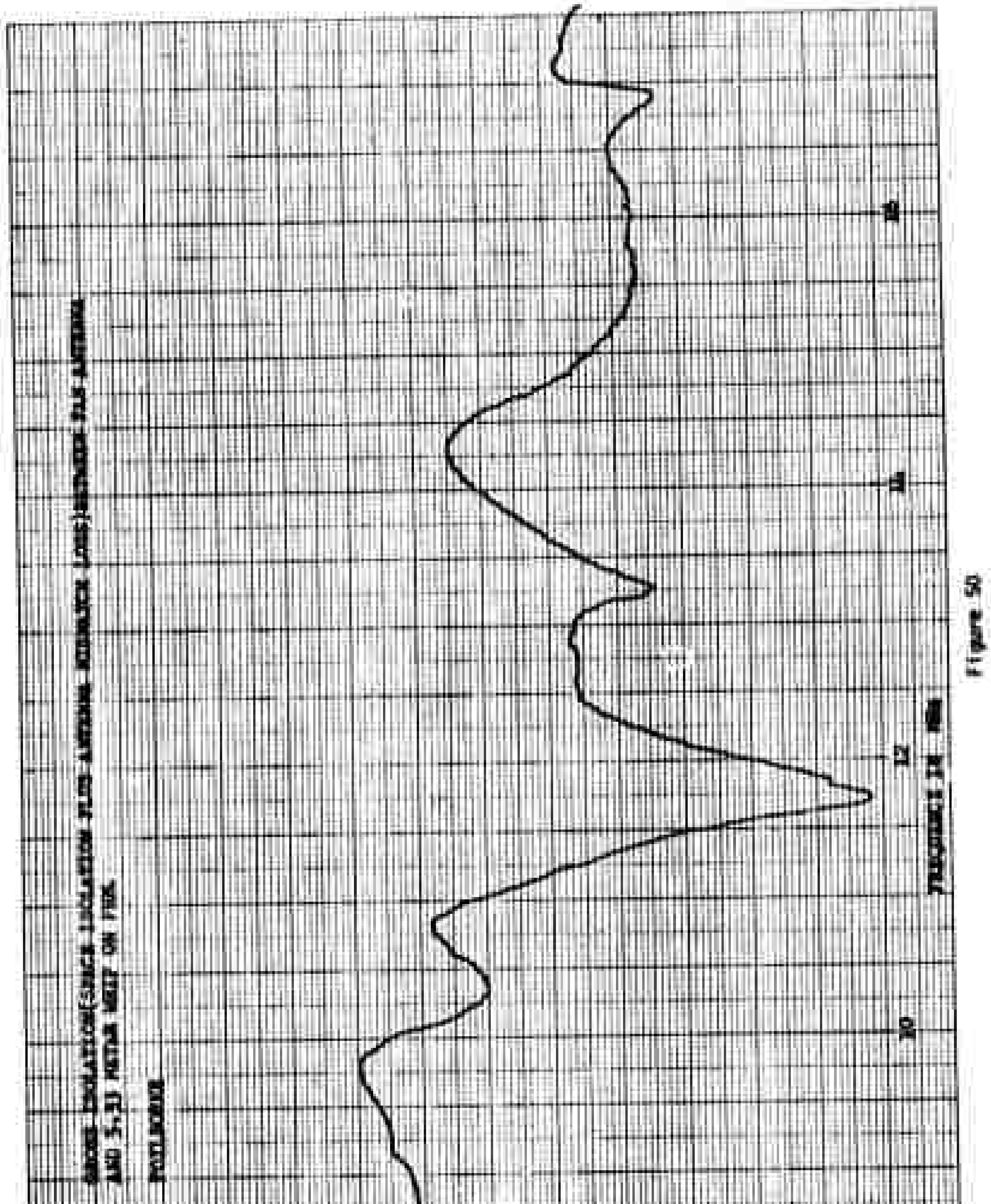


Figure 50

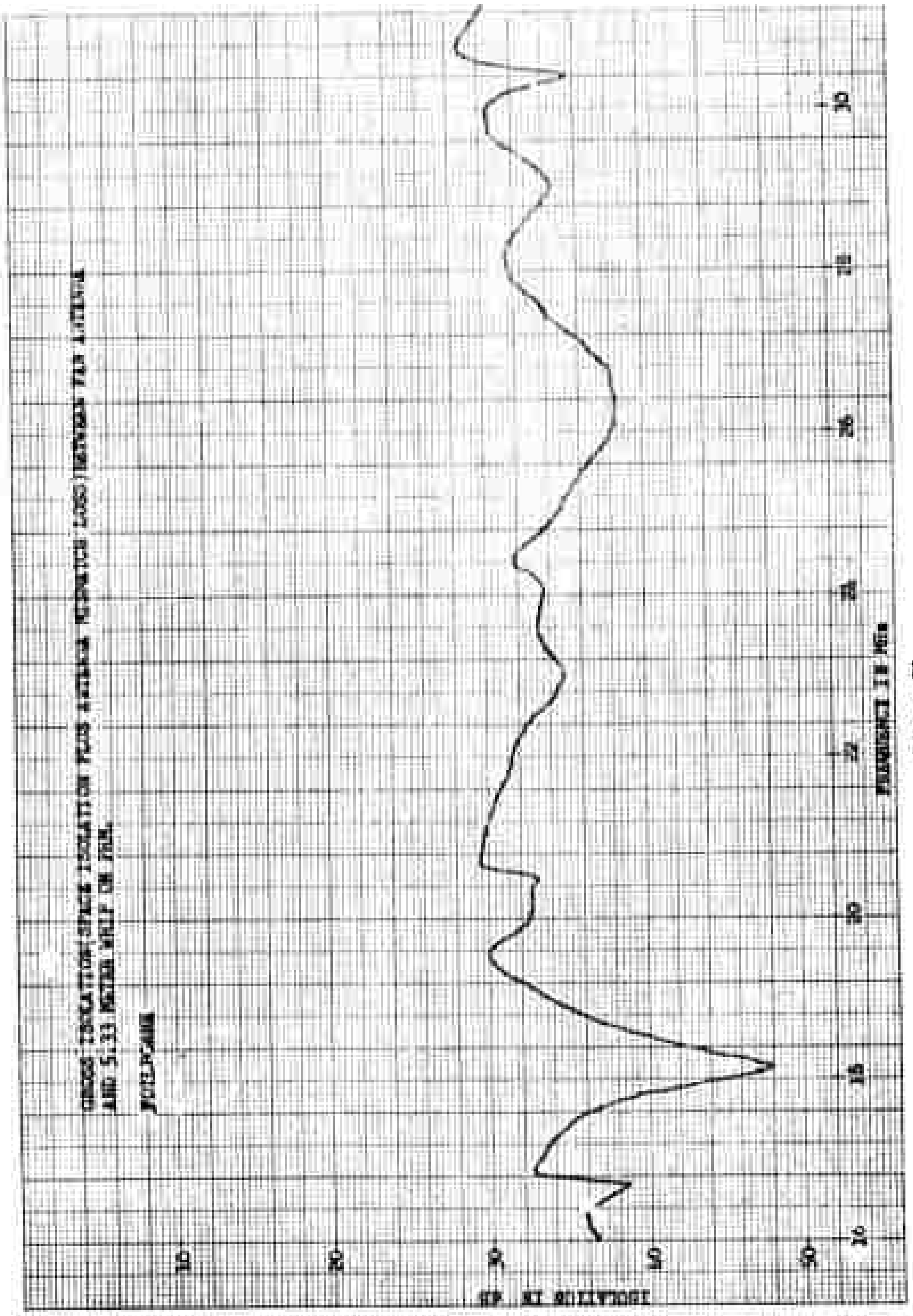


Figure 51

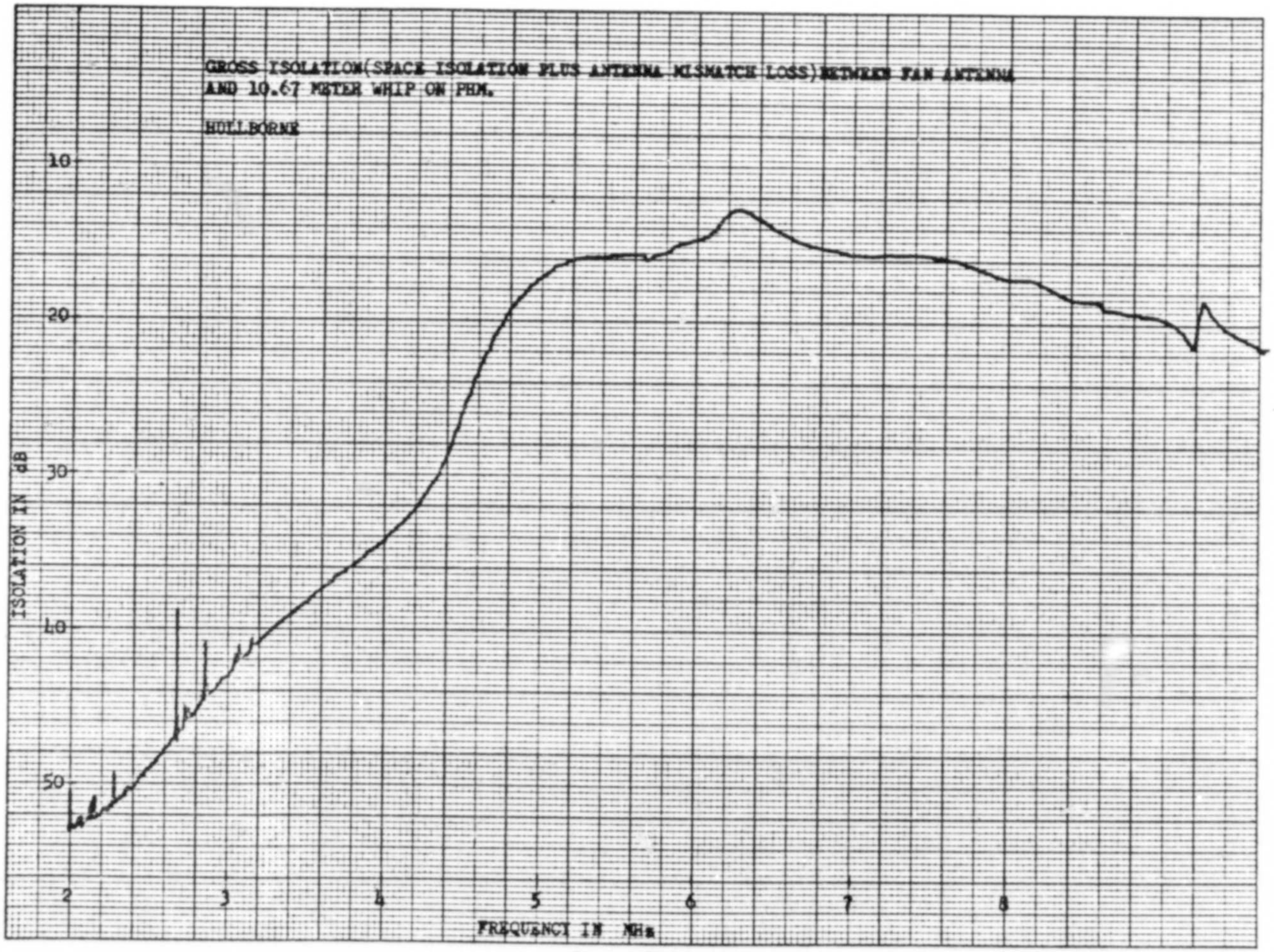

GROSS ISOLATION(SPACE ISOLATION PLUS ANTENNA MISMATCH LOSS)BETWEEN FAN ANTENNA
AND 10.67 METER WHIP ON PHM.
HULLBORNE
10
20
30
40
50
ISOLATION IN dB
2
3
4
5
6
7
8
FREQUENCY IN MHz

Figure 52

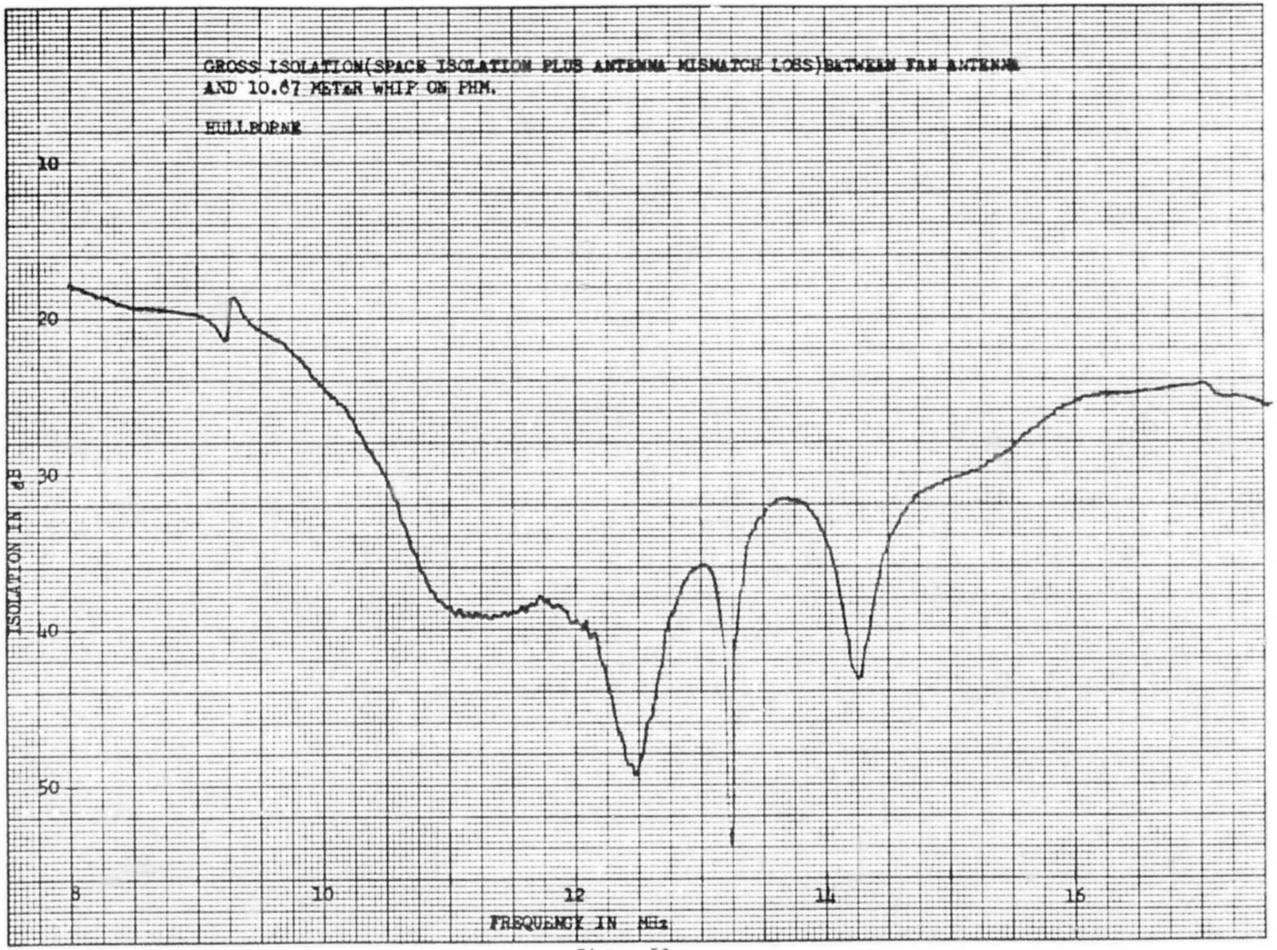

GROSS ISOLATION(SPACE ISOLATION PLUS ANTENNA MISMATCH LOSS)BETWEEN FAN ANTENNA
AND 10.67 METER WHIP ON PHM.
HULLBORNE
ISOLATION IN dB
10
20
30
40
50
8
10
12
14
16
FREQUENCY IN MHz

Figure 53

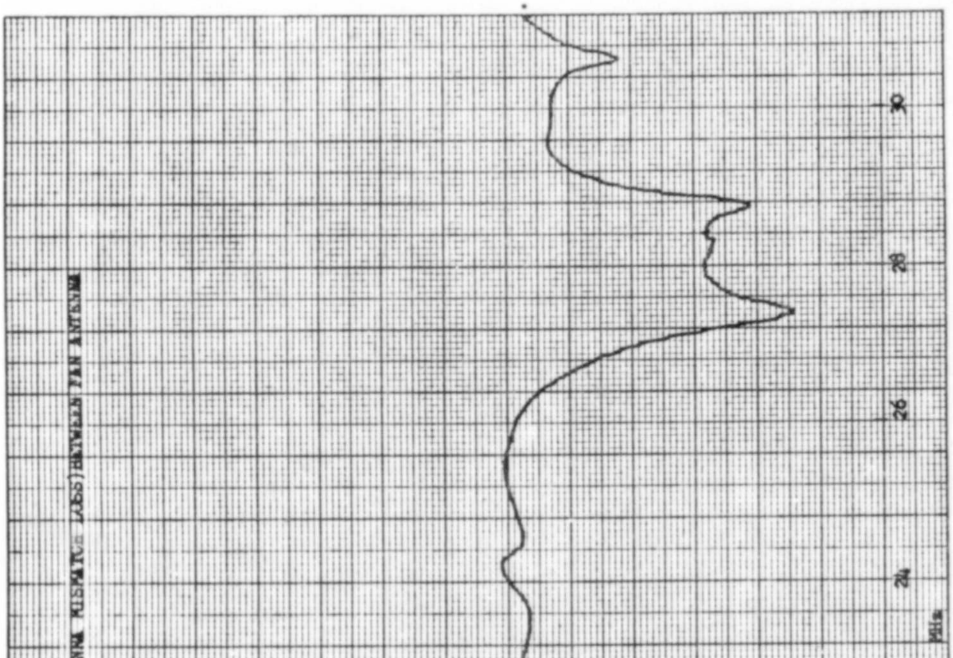

GROSS ISOLATION(SPACE ISOLATION PLUS ANTENNA MISMATCH LOSS)BETWEEN FAN ANTENNA AND 10.67 METER WHIP ON PHM.
HULLBORNE
ISOLATION IN dB
10
20
30
40
50
16
18
20
22
24
26
28
30
FREQUENCY IN MHz

Figure 54

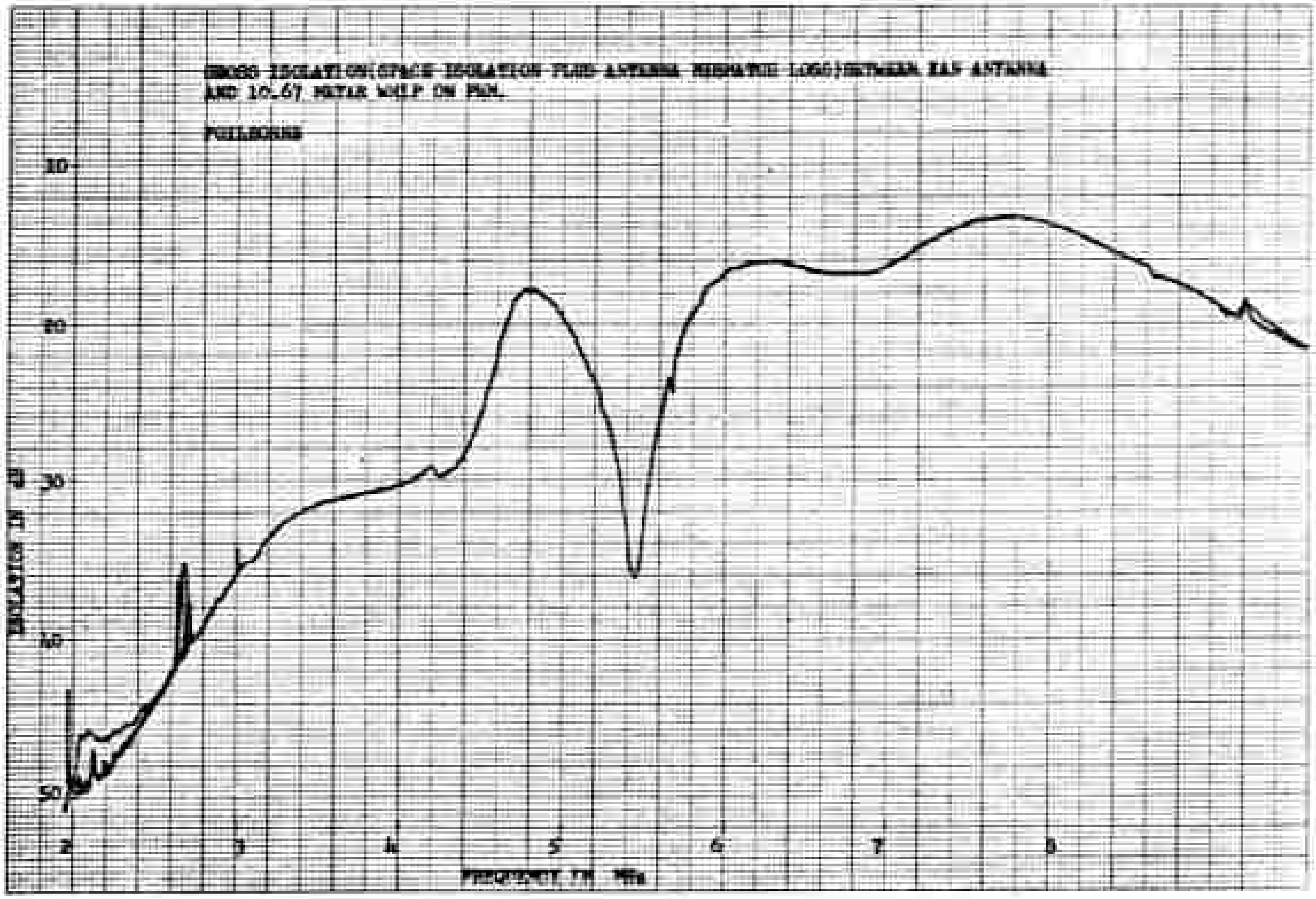


Figure 55

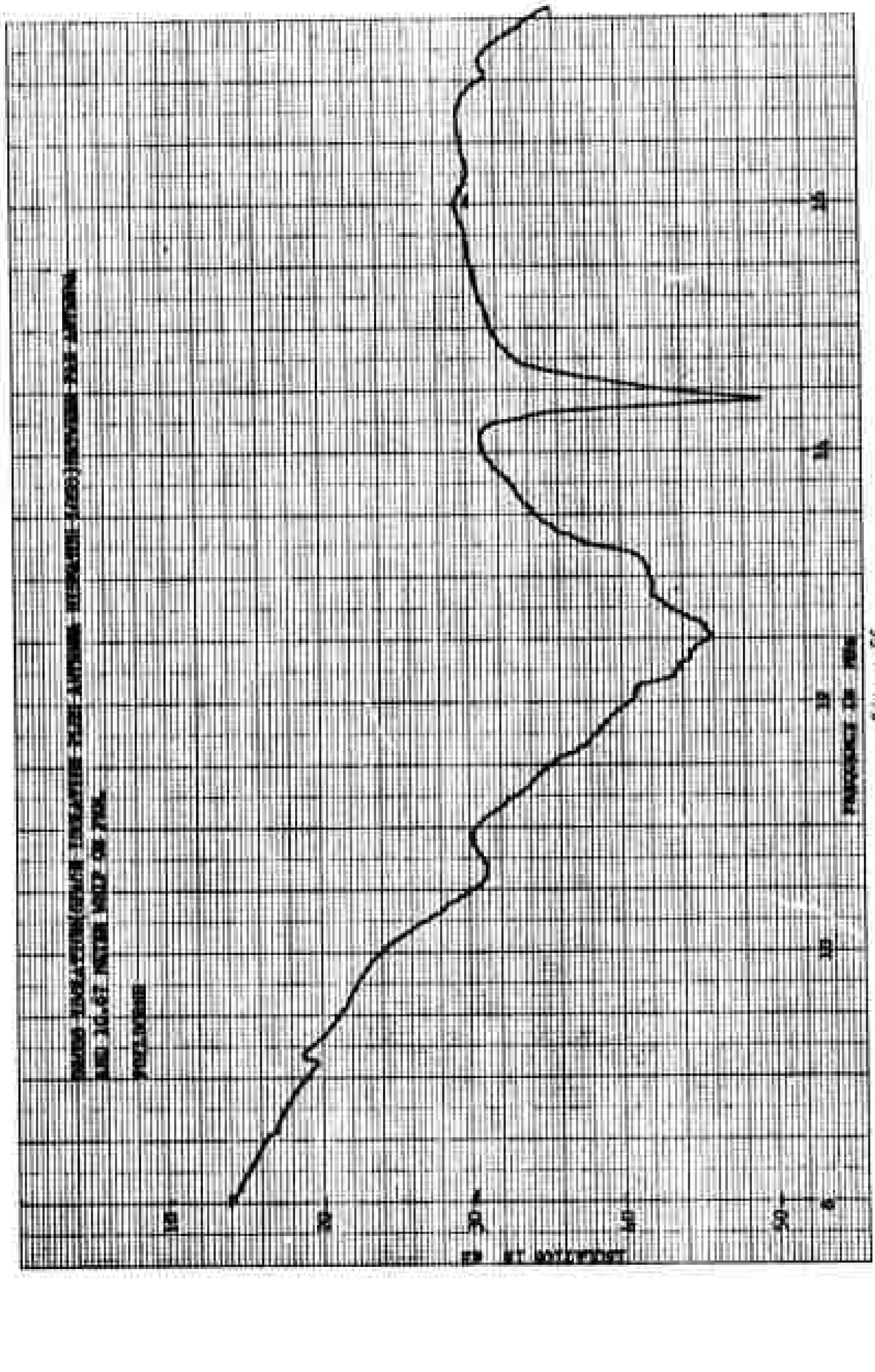


Figure 56

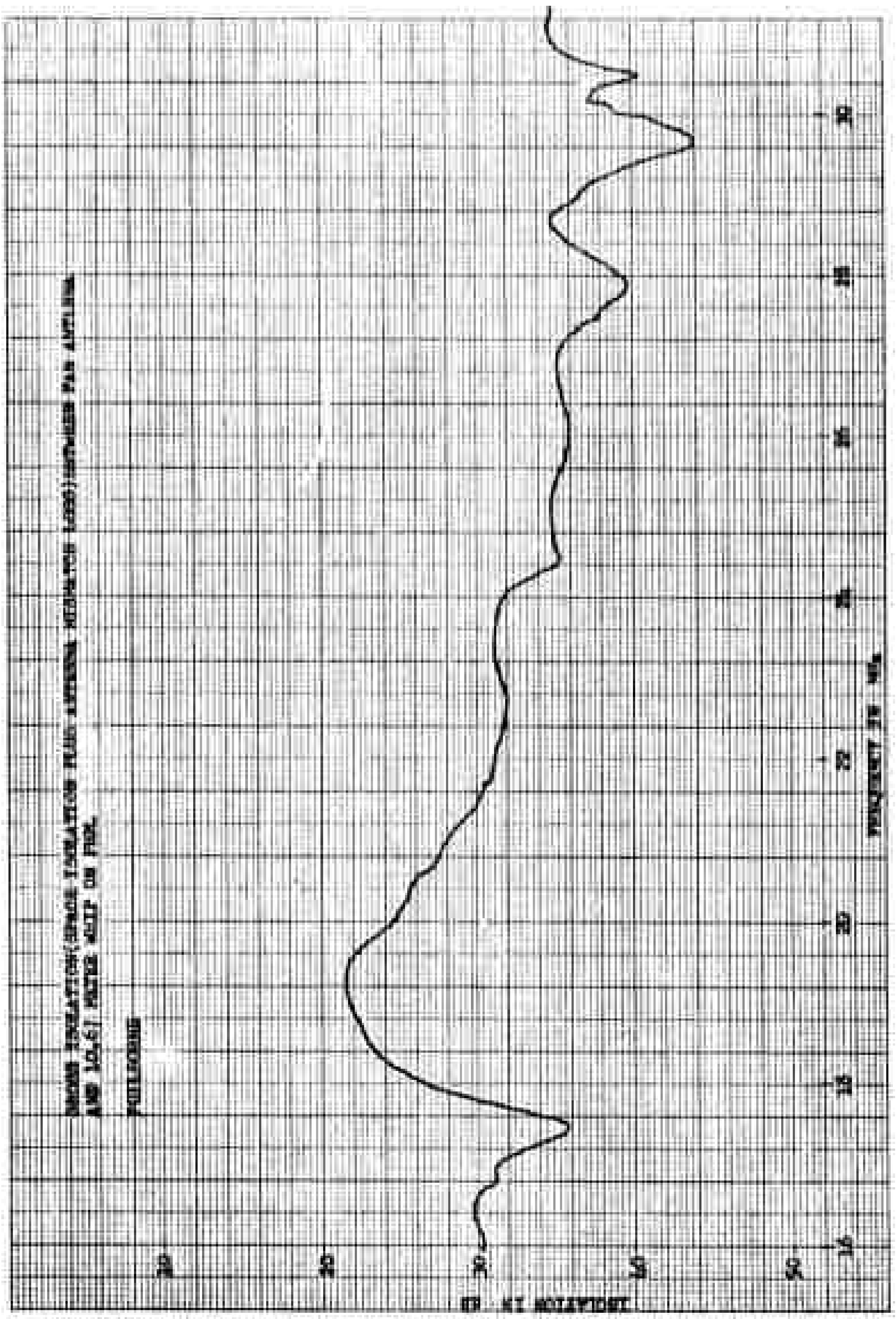


Figure 57

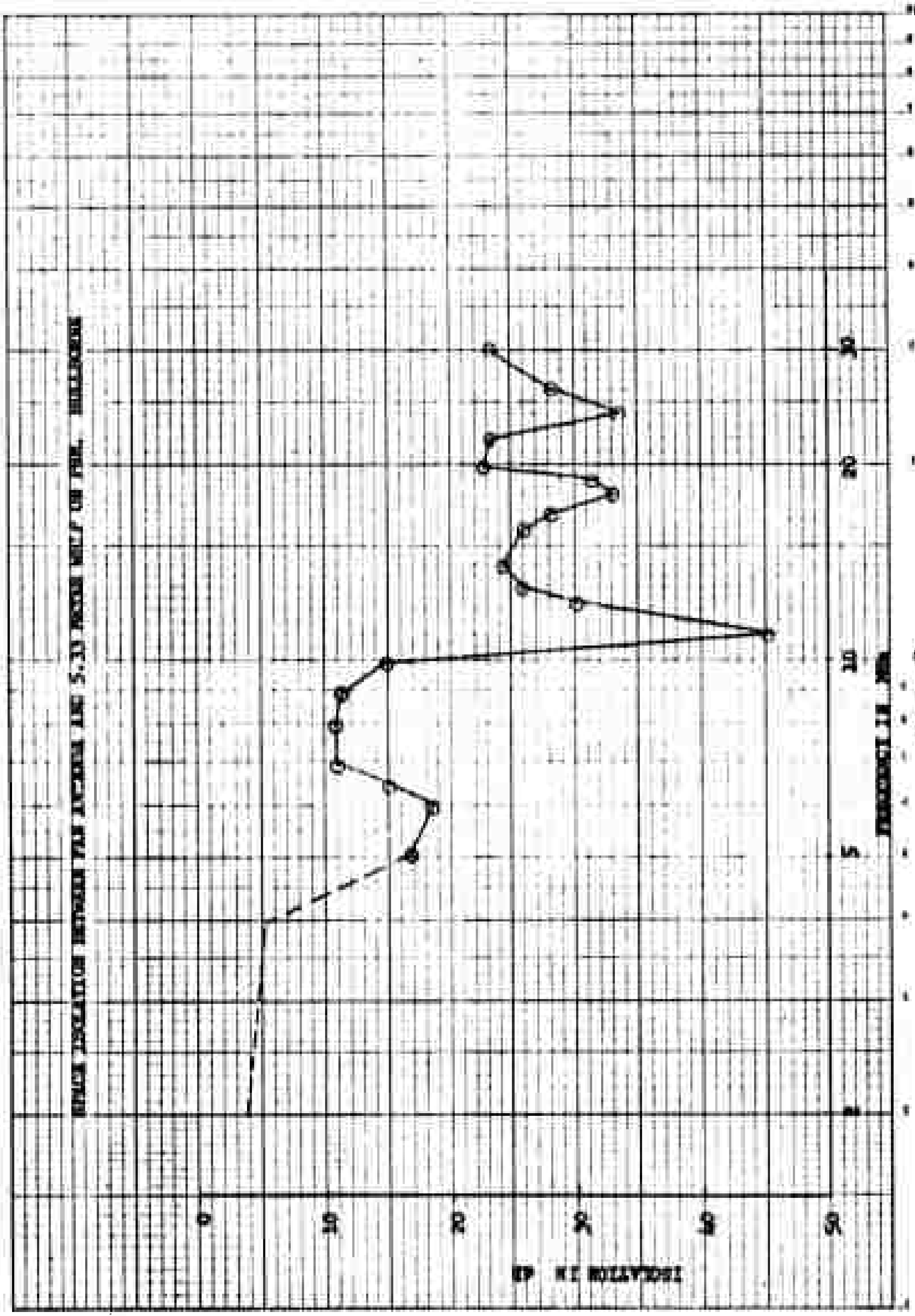


Figure 58

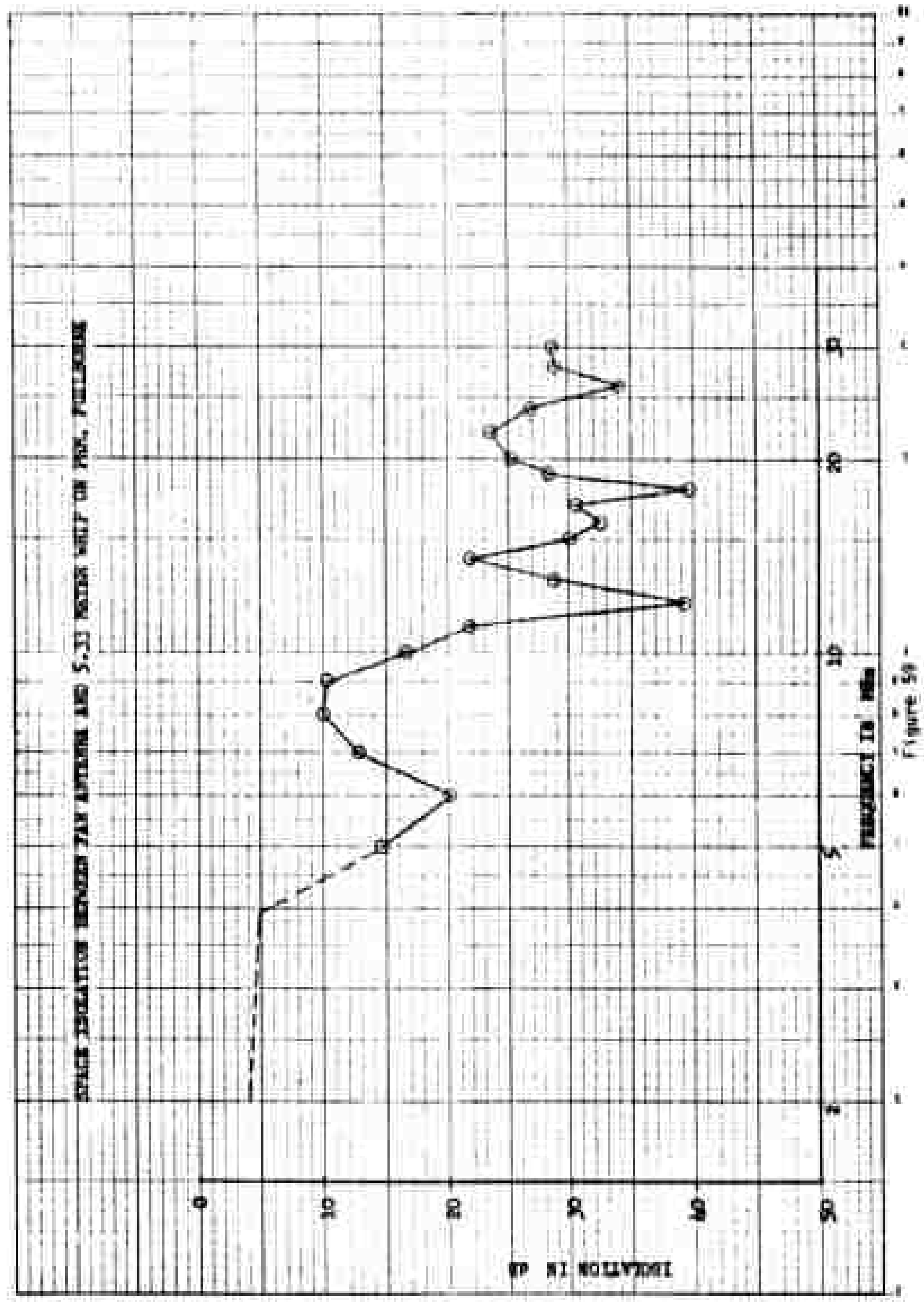


Figure 59

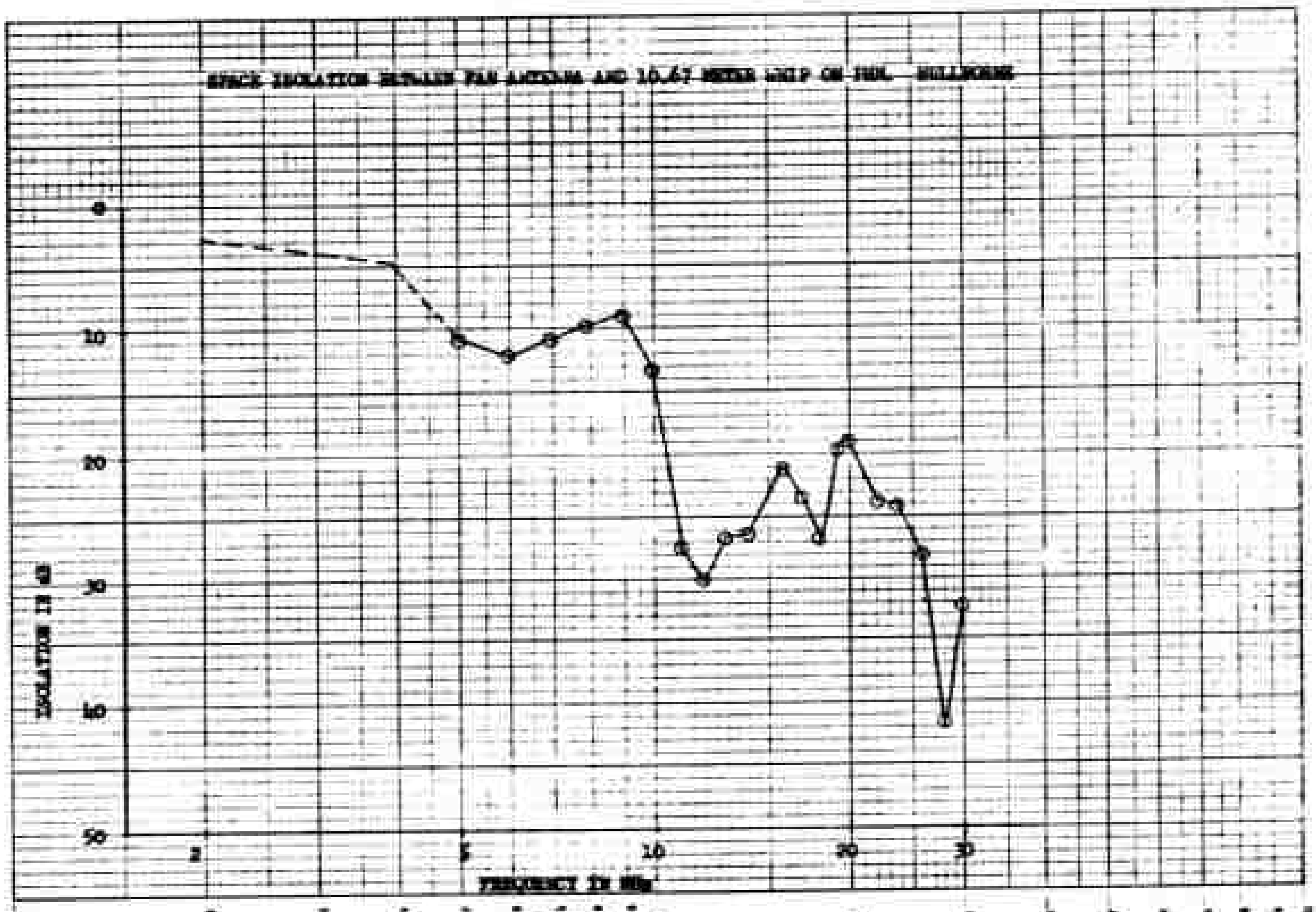


Figure 60

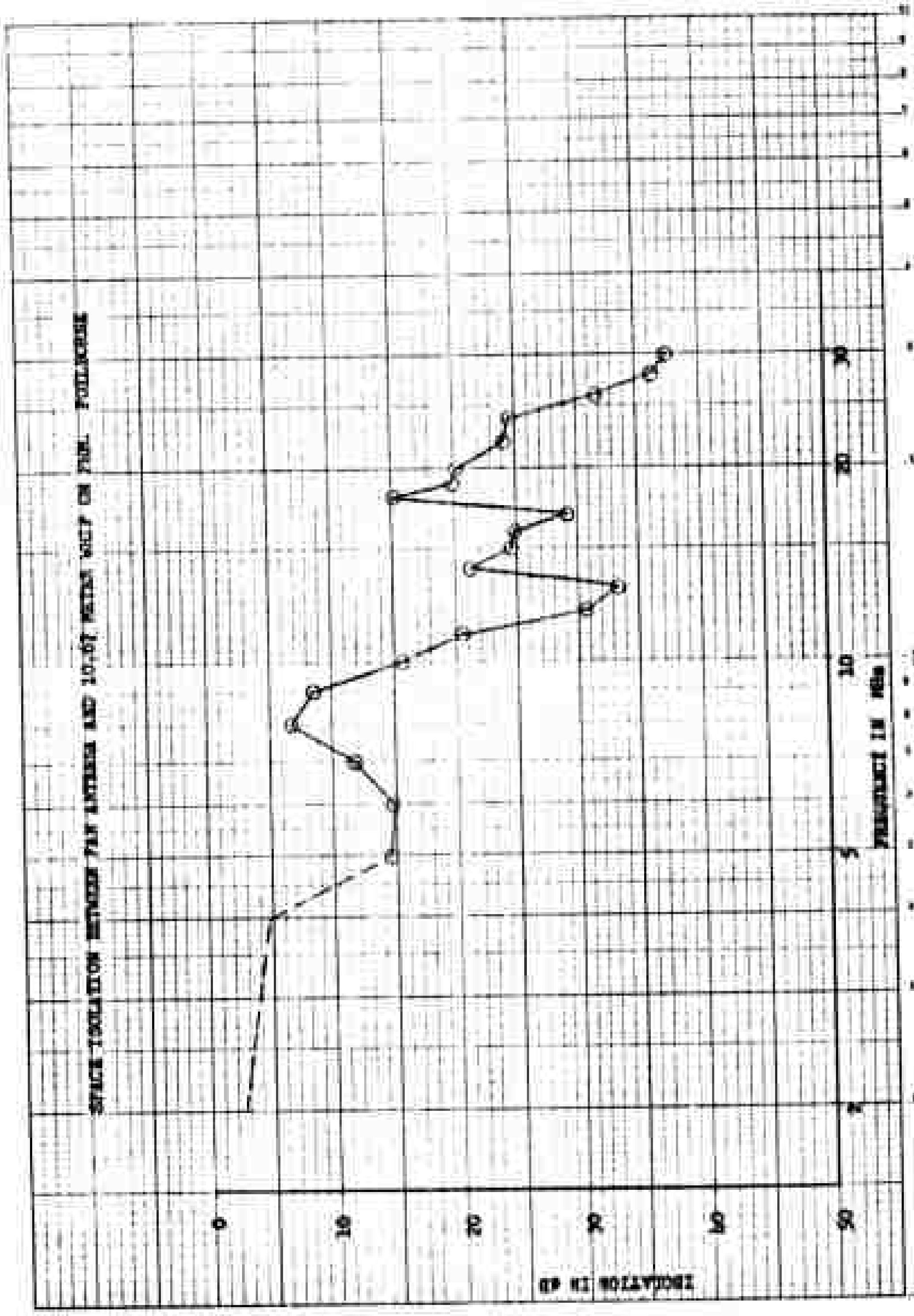

SPACE ISOLATION BETWEEN FAN ANTENNA AND 10.67 METER WHIP ON PHM. FOILBORNE
ISOLATION IN dB
0
10
20
30
40
50
2
5
10
20
30
FREQUENCY IN MHz

Figure 61

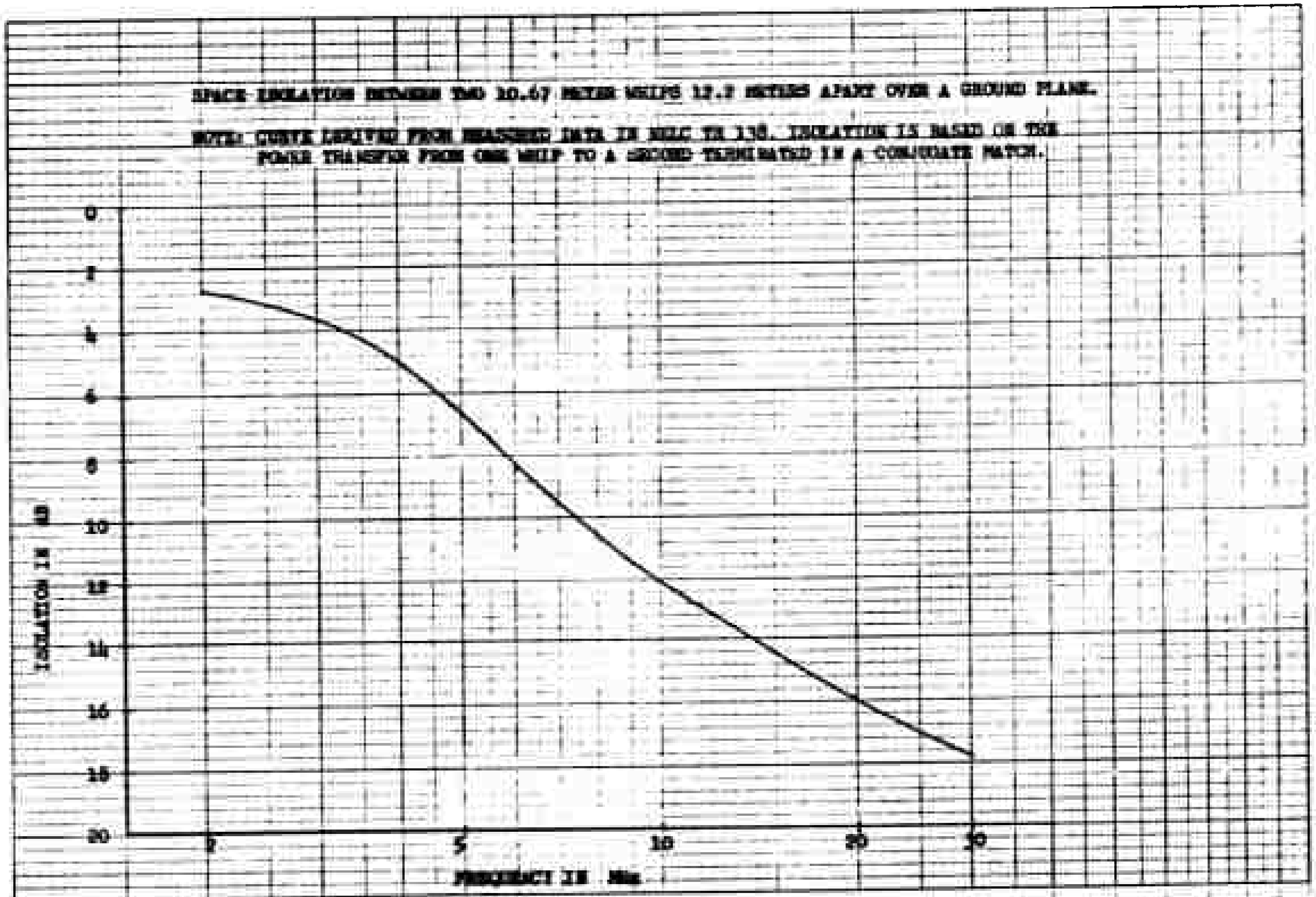

SPACE ISOLATION BETWEEN TWO 10.67 METER WHIPS 12.2 METERS APART OVER A GROUND PLANE.
NOTE: CURVE DERIVED FROM MEASURED DATA IN NELC TR 138. ISOLATION IS BASED ON THE POWER TRANSFER FROM ONE WHIP TO A SECOND TERMINATED IN A CONJUGATE MATCH.
ISOLATION IN dB
0
2
4
6
8
10
12
14
16
18
20
2
5
10
20
30
FREQUENCY IN MHz

Figure 62

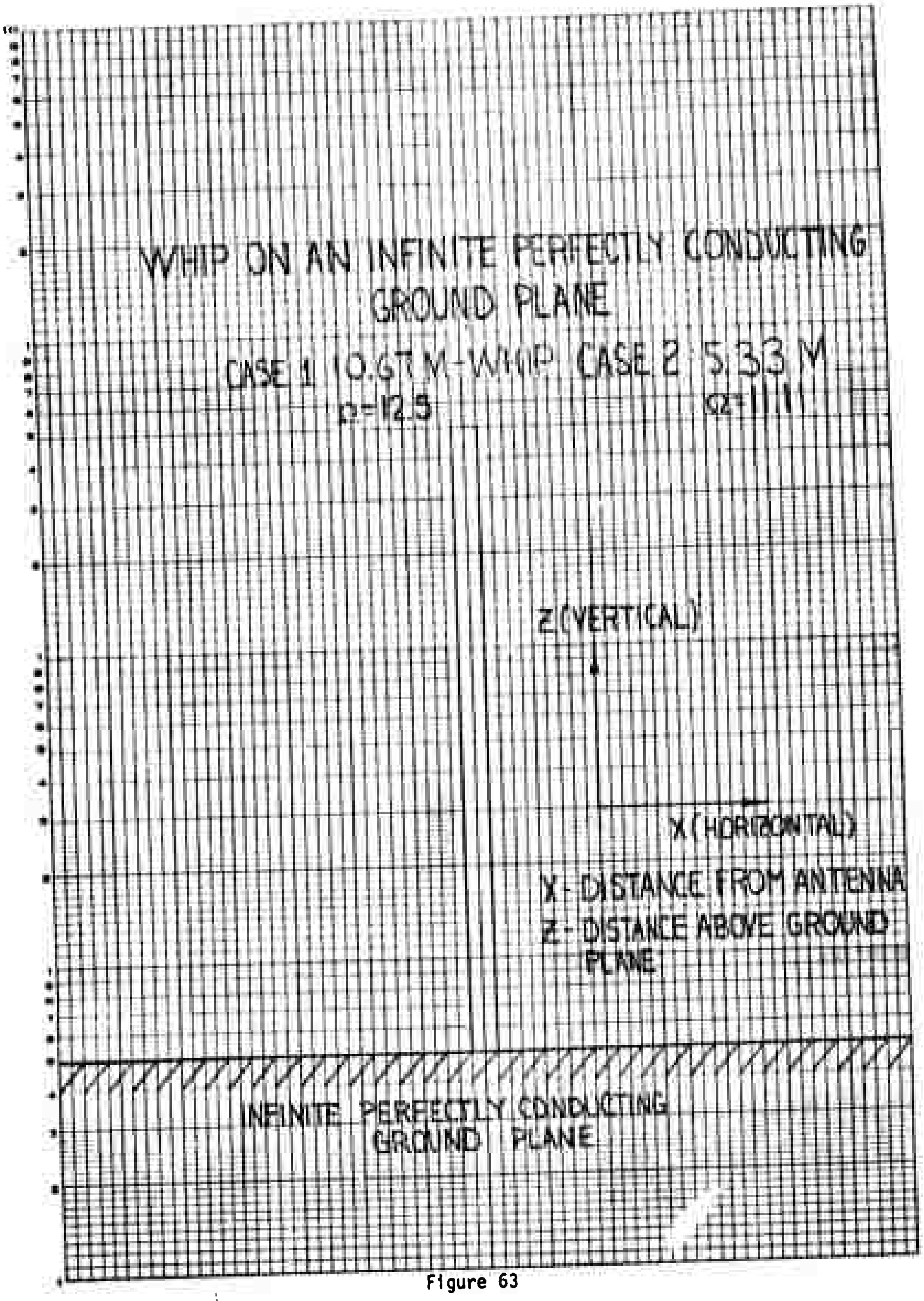

WHIP ON AN INFINITE PERFECTLY CONDUCTING
GROUND PLANE
CASE 1 10.67 M-WHIP CASE 2 5.33 M
Z (VERTICAL)
X (HORIZONTAL)
X - DISTANCE FROM ANTENNA
Z - DISTANCE ABOVE GROUND
PLANE
INFINITE PERFECTLY CONDUCTING
GROUND PLANE

Figure 63

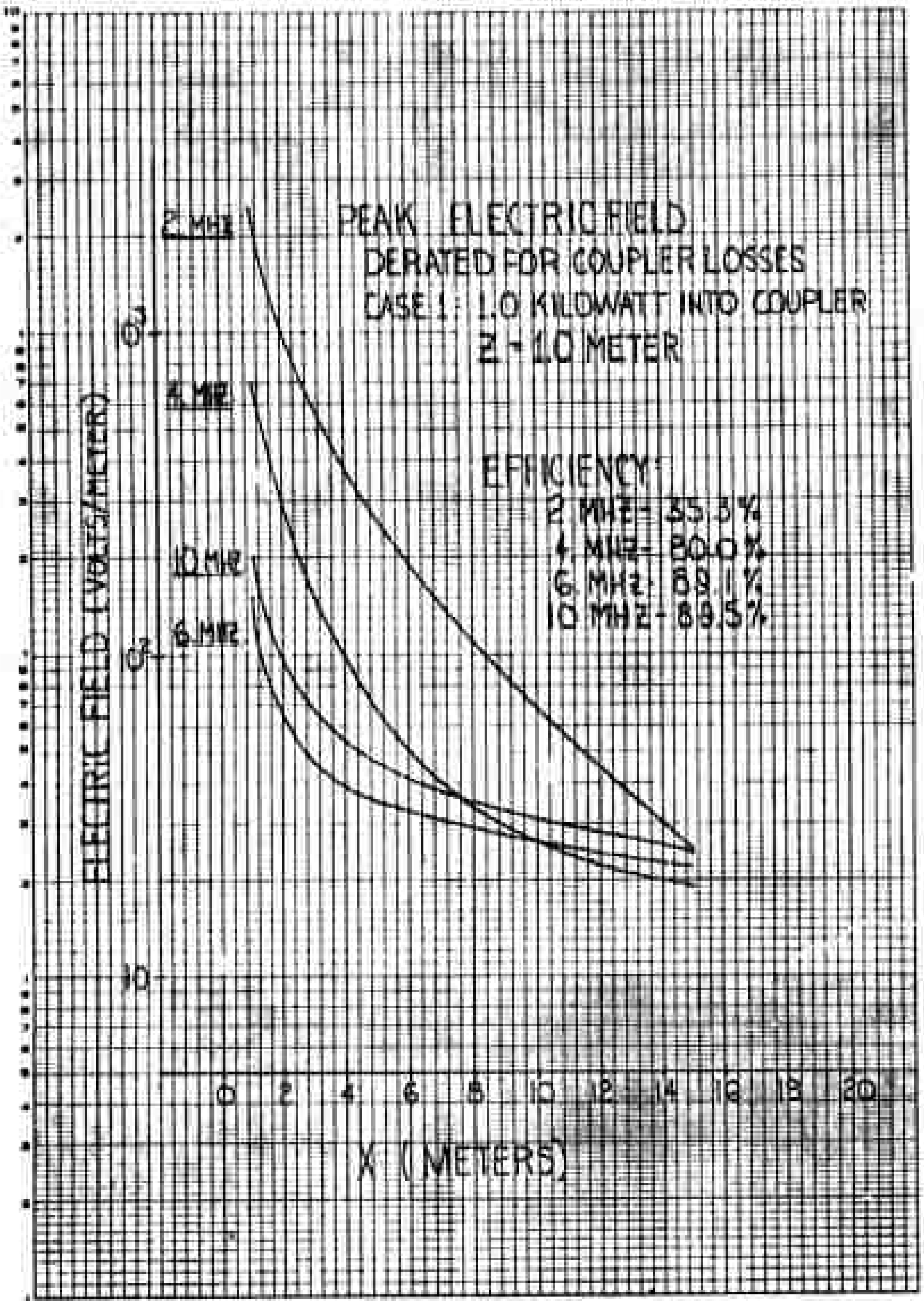

PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 1: 1.0 KILOWATT INTO COUPLER
Z = 10 METER
EFFICIENCY:
2 MHZ - 35.3%
4 MHZ - 80.0%
6 MHZ - 68.1%
10 MHZ - 89.5%
2 MHZ
4 MHZ
10 MHZ
6 MHZ
10^3
10^2
10
ELECTRIC FIELD (VOLTS/METER)
0
2
4
6
8
10
12
14
16
18
20
X (METERS)

Figure 64

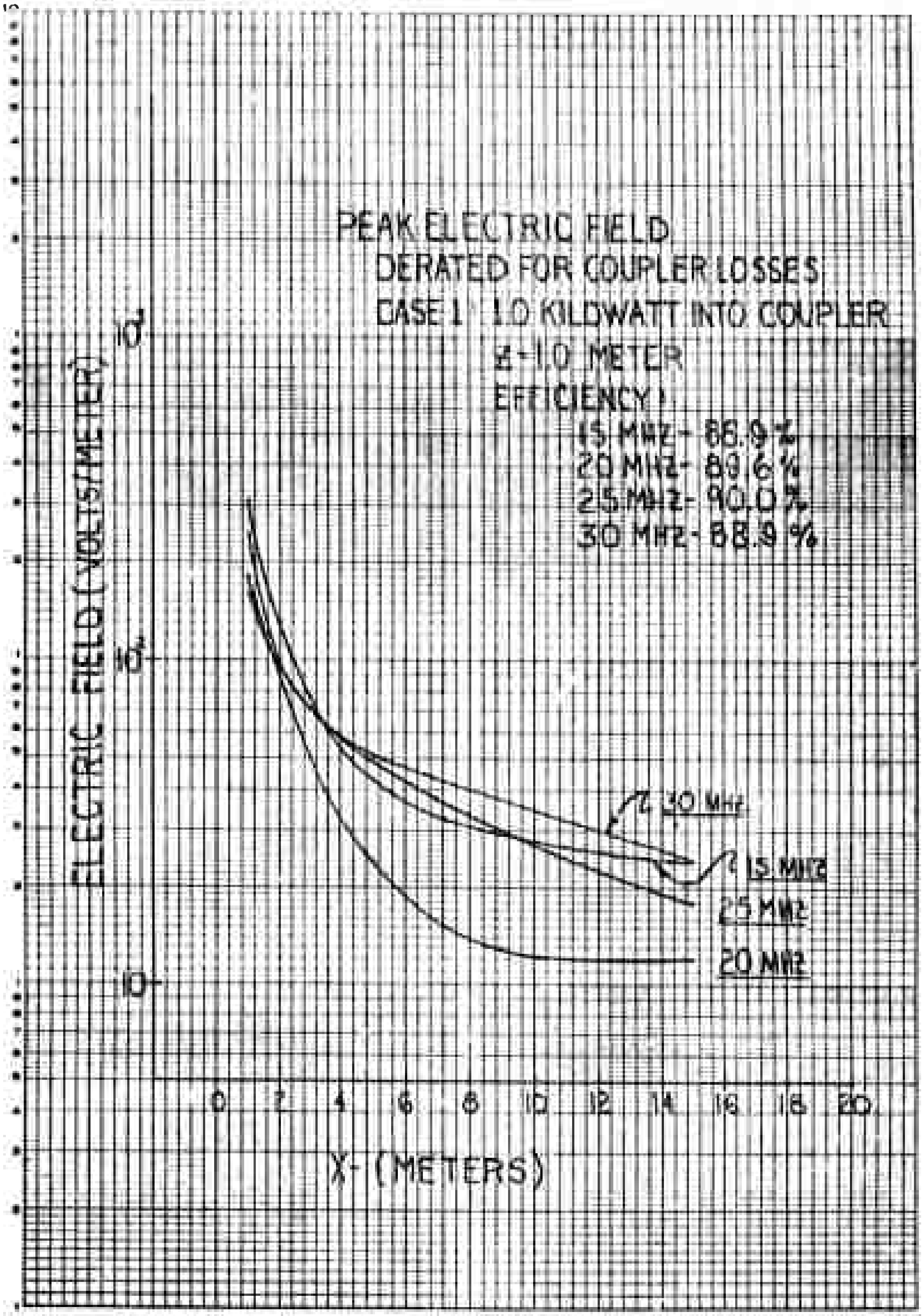
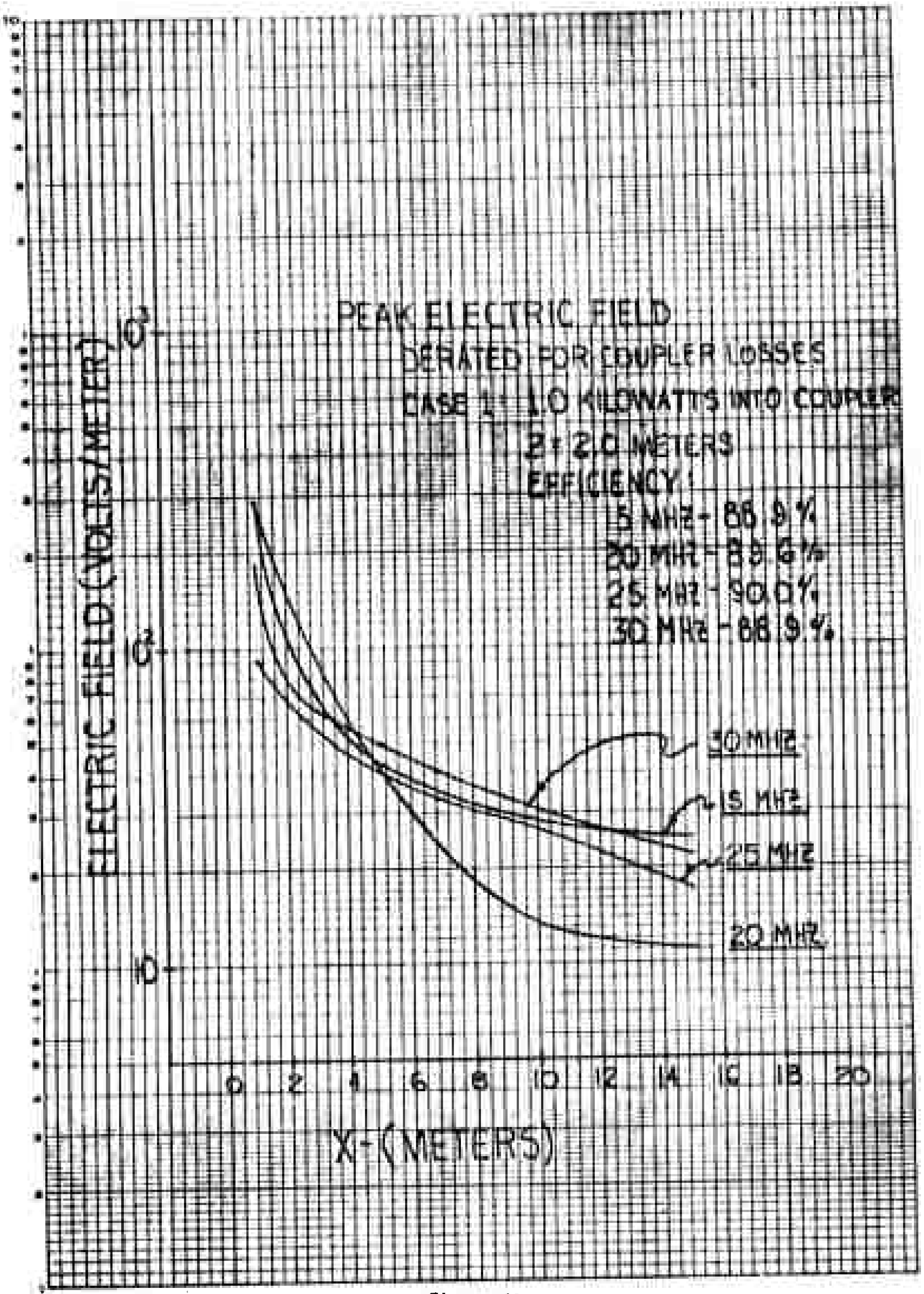

PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 1 1.0 KILOWATT INTO COUPLER
Z=1.0 METER
EFFICIENCY:
15 MHz - 86.9%
20 MHz - 89.6%
25 MHz - 90.0%
30 MHz - 88.9%
ELECTRIC FIELD (VOLTS/METER)
10^3
10^2
10
0
2
4
6
8
10
12
14
16
18
20
X- (METERS)
30 MHz
15 MHz
25 MHz
20 MHz

Figure 65



PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 1: 1.0 KILOWATTS INTO COUPLER
Z = 2.0 METERS
EFFICIENCY:
15 MHz - 88.9%
20 MHz - 89.6%
25 MHz - 90.0%
30 MHz - 88.9%
ELECTRIC FIELD (VOLTS/METER)
10^3
10^2
10
30 MHz
15 MHz
25 MHz
20 MHz
0
2
4
6
8
10
12
14
16
18
20
X - (METERS)

Figure 67

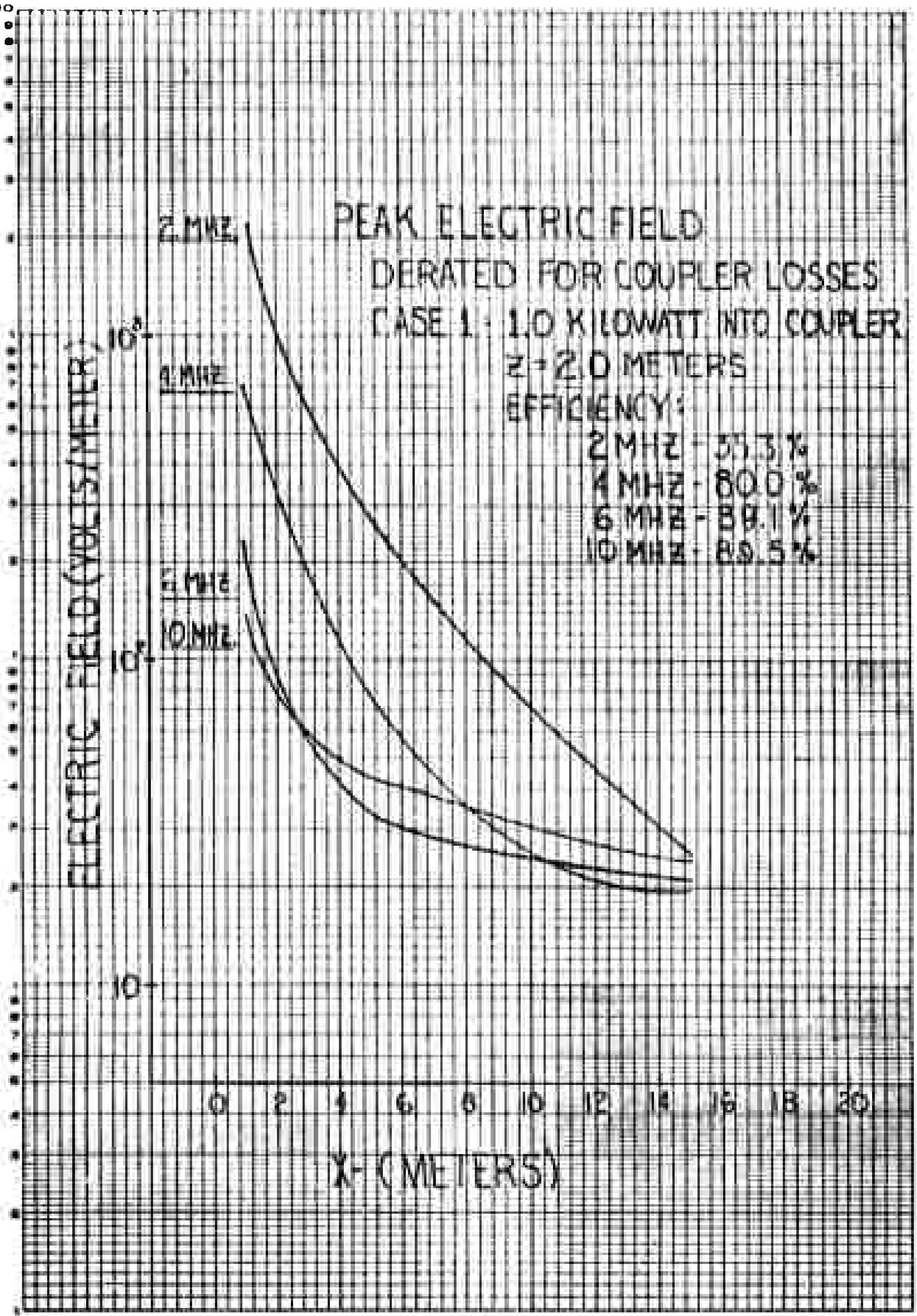

PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 1 - 1.0 KILOWATT INTO COUPLER
Z = 2.0 METERS
EFFICIENCY:
2 MHZ - 33.3%
4 MHZ - 80.0%
6 MHZ - 89.1%
10 MHZ - 85.5%
2 MHZ
4 MHZ
6 MHZ
10 MHZ
ELECTRIC FIELD (VOLTS/METER)
10^3
10^2
10
0
2
4
6
8
10
12
14
16
18
20
X - (METERS)

Figure 66

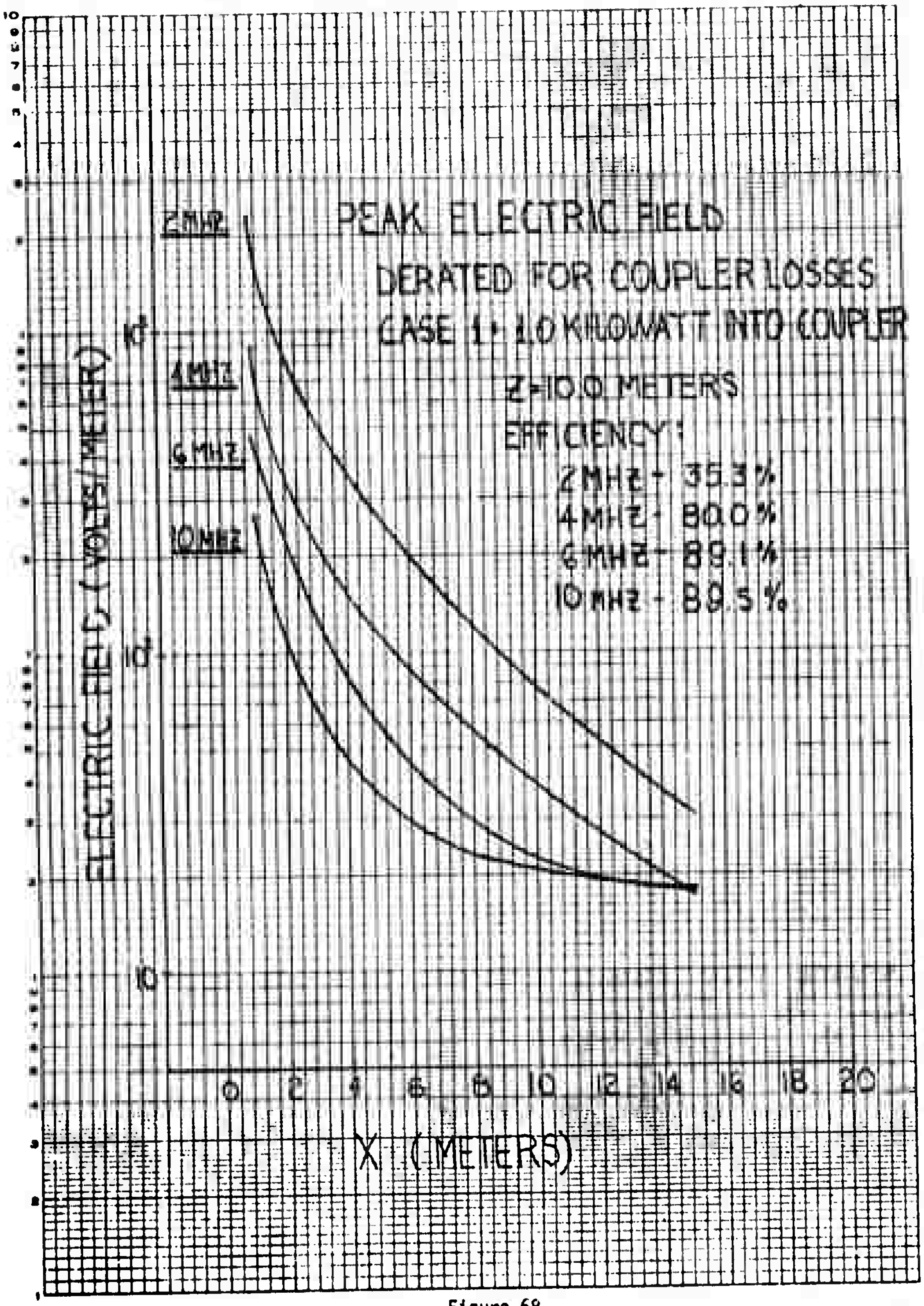

PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 1: 1.0 KILOWATT INTO COUPLER
Z=10.0 METERS
EFFICIENCY:
2MHz - 35.3%
4MHz - 80.0%
6MHz - 89.1%
10MHz - 89.5%
2MHz
4MHz
6MHz
10MHz
ELECTRIC FIELD (VOLTS/METER)
10^3
10^2
10
0 2 4 6 8 10 12 14 16 18 20
X (METERS)

Figure 68

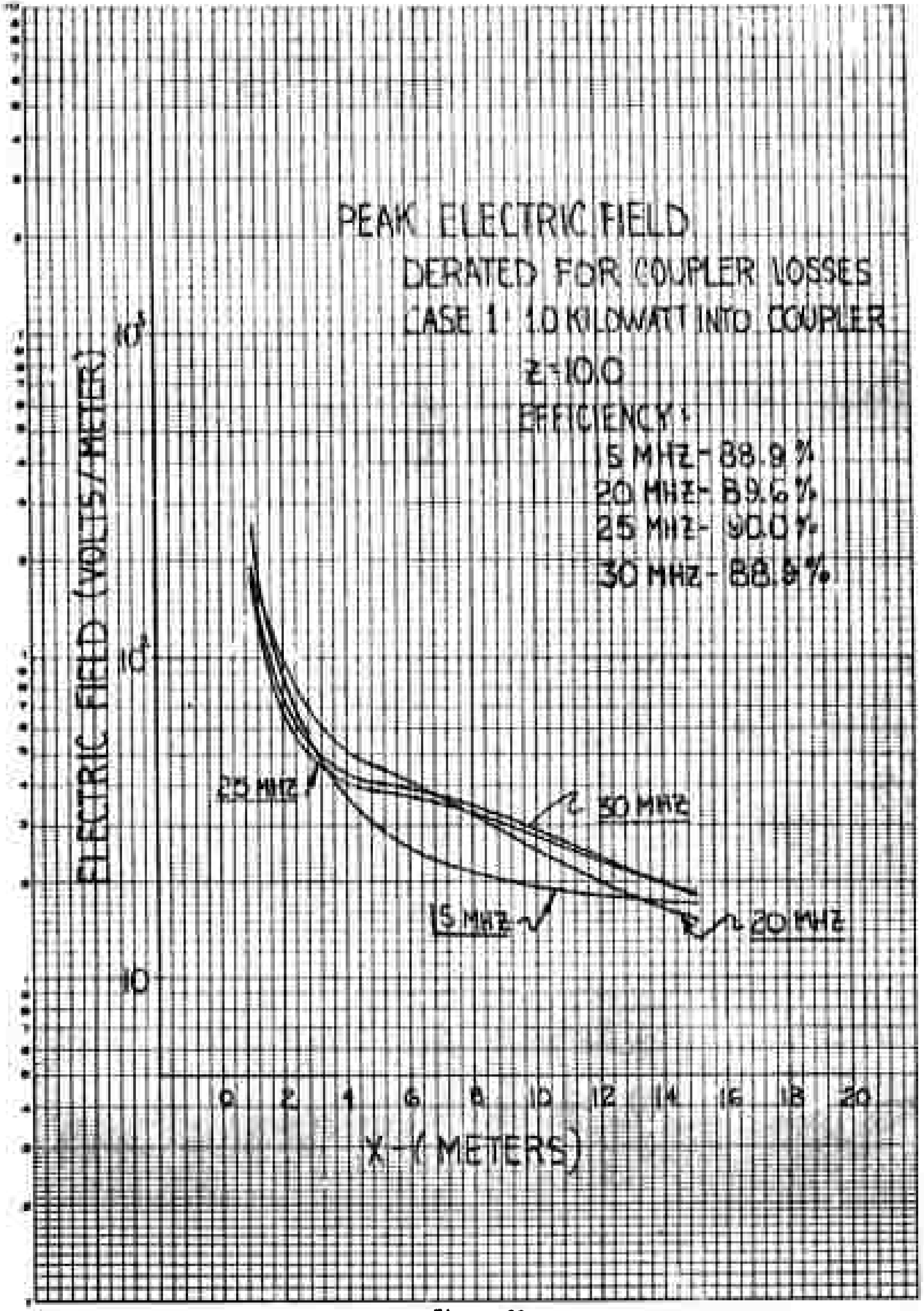

PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 1 1.0 KILOWATT INTO COUPLER
Z=100
EFFICIENCY:
15 MHz - 88.9%
20 MHz - 89.6%
25 MHz - 90.0%
30 MHz - 88.9%
ELECTRIC FIELD (VOLTS/METER)
10^3
10^2
10
25 MHz
30 MHz
15 MHz
20 MHz
0
2
4
6
8
10
12
14
16
18
20
X-(METERS)

Figure 69

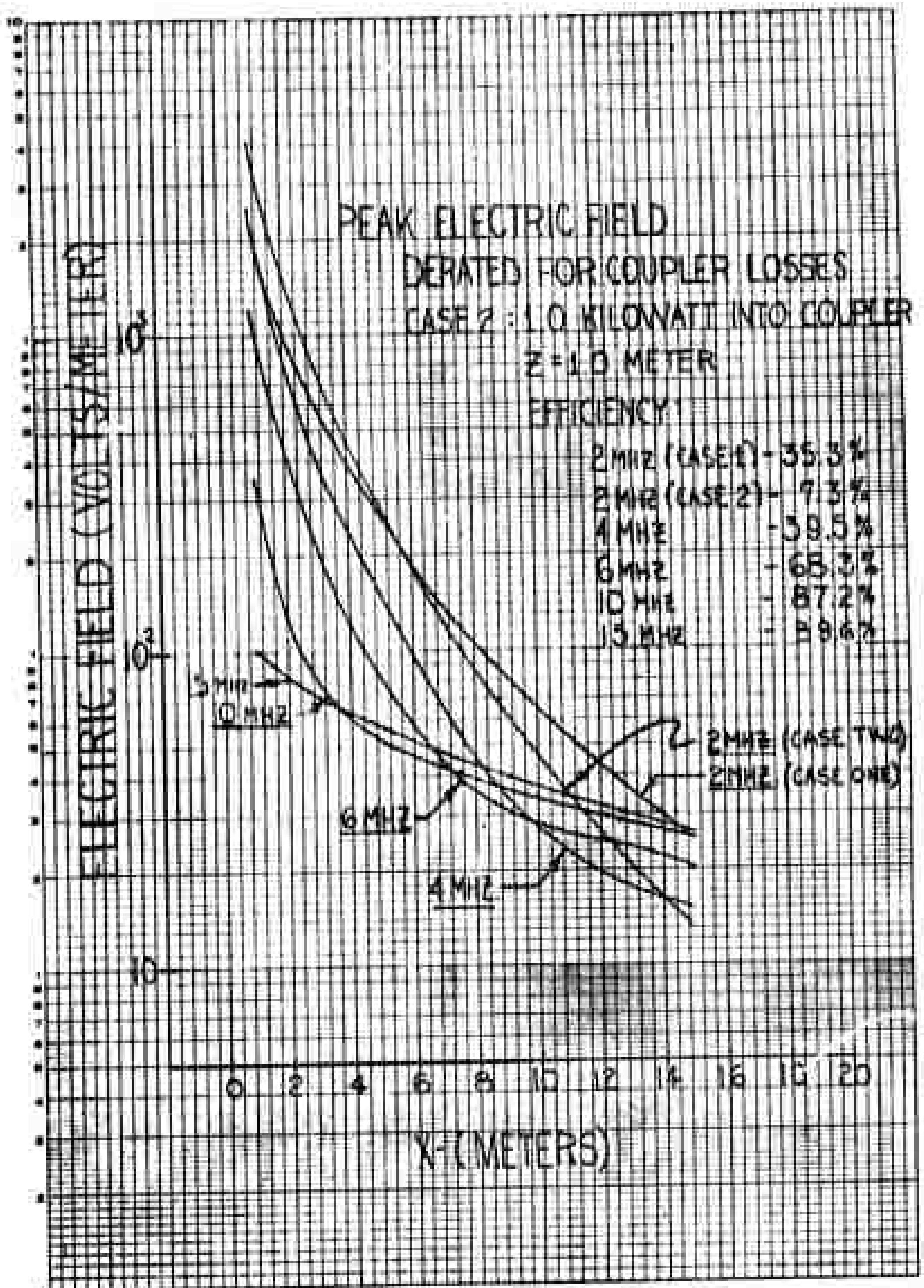

PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 2 : 1.0 KILOWATT INTO COUPLER
Z = 1.0 METER
EFFICIENCY:
2 MHZ (CASE 1) - 35.3%
2 MHZ (CASE 2) - 7.3%
4 MHZ - 39.5%
6 MHZ - 68.3%
10 MHZ - 87.2%
15 MHZ - 89.6%
15 MHZ
10 MHZ
6 MHZ
4 MHZ
2 MHZ (CASE TWO)
2 MHZ (CASE ONE)
ELECTRIC FIELD (VOLTS/METER)
10^3
10^2
10
0 2 4 6 8 10 12 14 16 18 20
X-(METERS)

Figure 70

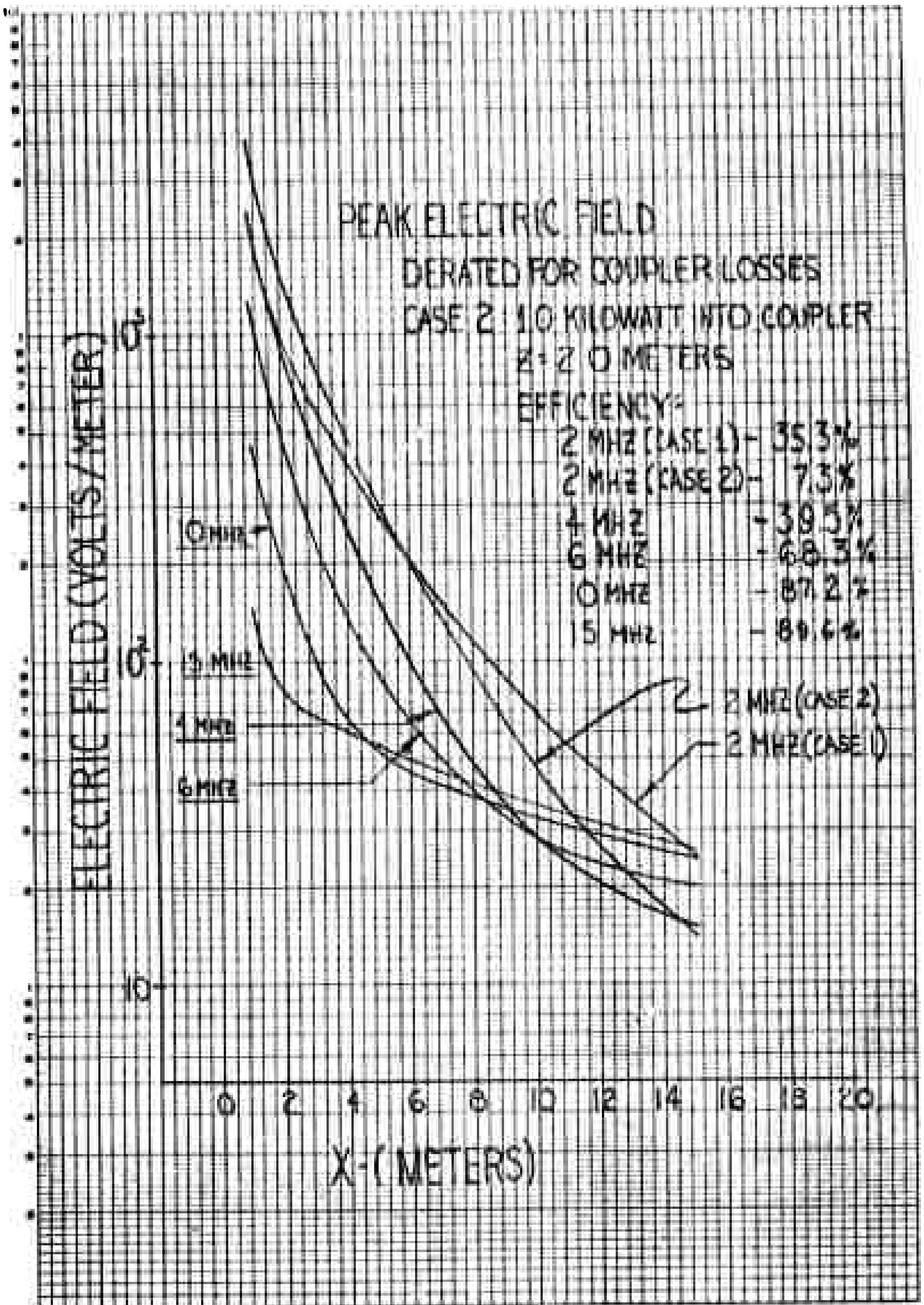

PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 2 1.0 KILOWATT INTO COUPLER
Z = 2.0 METERS
EFFICIENCY =
2 MHz (CASE 1) - 35.3%
2 MHz (CASE 2) - 7.3%
4 MHz - 39.5%
6 MHz - 68.3%
10 MHz - 87.2%
15 MHz - 89.6%
2 MHz (CASE 2)
2 MHz (CASE 1)
10 MHz
15 MHz
4 MHz
6 MHz
ELECTRIC FIELD (VOLTS/METER)
10^3
10^2
10
0 2 4 6 8 10 12 14 16 18 20
X-(METERS)

Figure 71

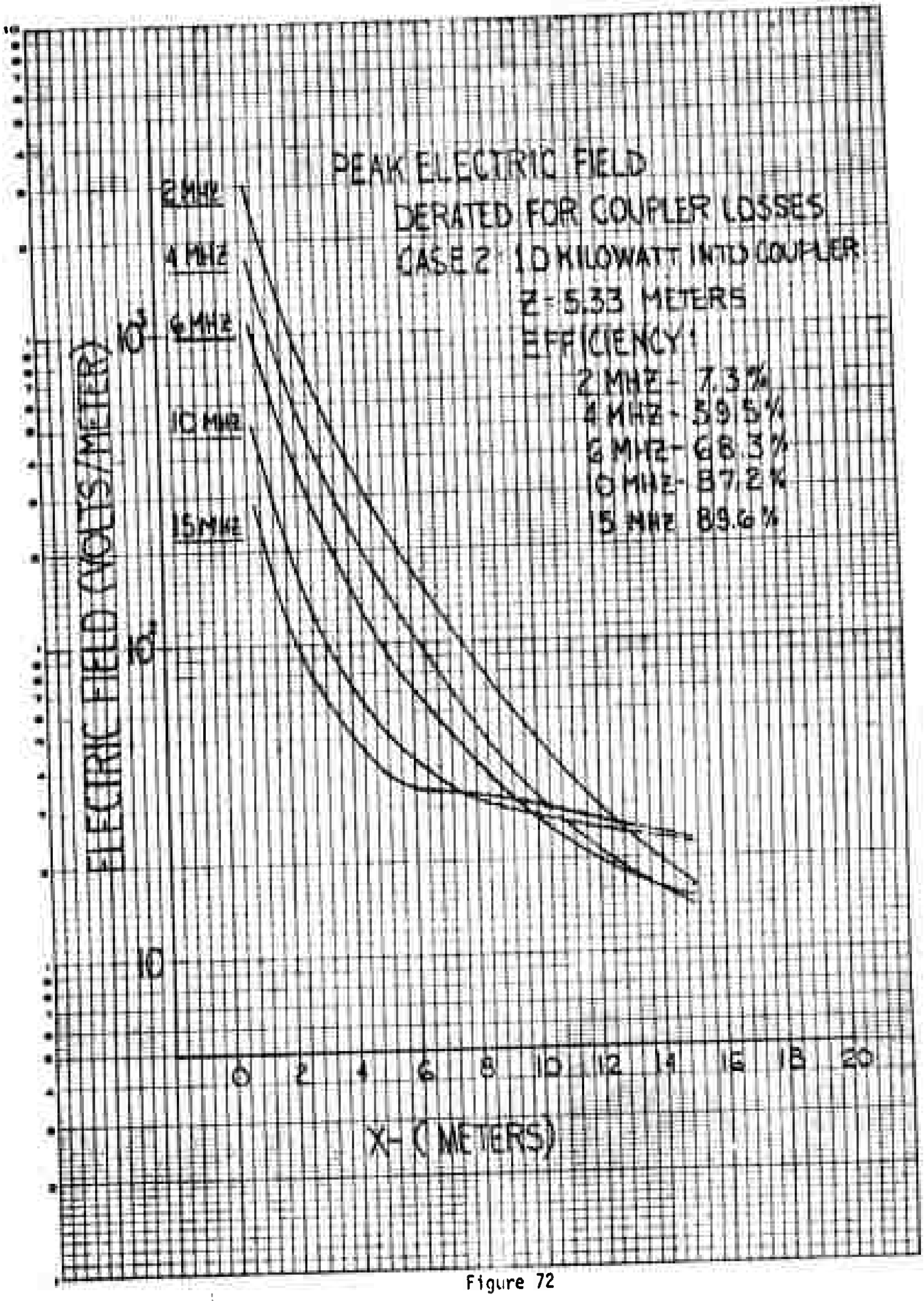
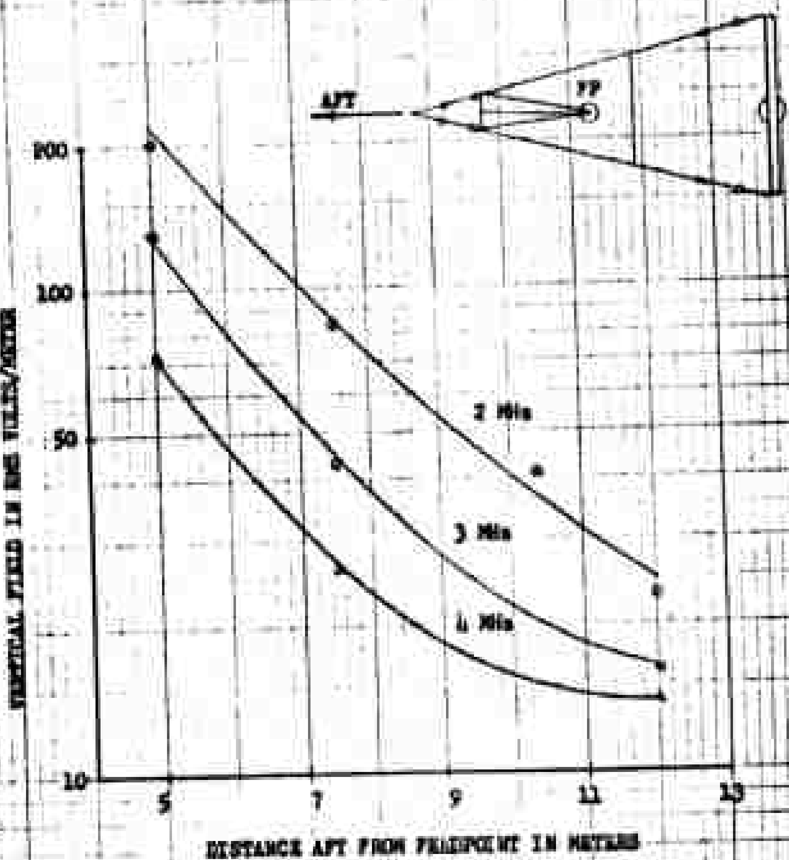

PEAK ELECTRIC FIELD
DERATED FOR COUPLER LOSSES
CASE 2: 10 KILOWATT INTO COUPLER
Z-5.33 METERS
EFFICIENCY:
2 MHZ - 7.3%
4 MHZ - 39.5%
6 MHZ - 68.3%
10 MHZ - 87.2%
15 MHZ 89.6%
2 MHZ
4 MHZ
6 MHZ
10 MHZ
15 MHZ
ELECTRIC FIELD (VOLTS/METER)
10³
10²
10
0
2
4
6
8
10
12
14
16
18
20
X- (METERS)

Figure 72

MEASURED VERTICAL COMPONENT OF THE NEAR FIELD AT 1 METER ABOVE GROUND FOR THE FULL SCALE PHN FAN ANTENNA WHEN MOUNTED OVER A GROUND PLANE



CONDITIONS: 1. TRANSMITTER OUPUT 1 KW
2. FAN FED THROUGH 490T COUPLER
3. COUPLER LOSSES ARE;

2 MHz	5.1 dB
3 "	3,5 "
4 "	2.8 "

Figure 73

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Electronics Laboratory Center San Diego, California 92152	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

HF ANTENNA SYSTEM DESIGN FOR PATROL HYDROFOIL (MISSILE) (PHM)

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

J. L. Lievens and I. C. Olson

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
20 August 1973	84	3

8a. CONTRACT OR GRANT NO. b. PROJECT NO. S4663, Task 016 (NELC J605) c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) NELC Technical Document 269 9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Naval Ship Systems Command PMS-303.6

13. ABSTRACT

The PHM is a high-speed patrol craft under development for possible NATO use. Small size, along with extensive weapon and communications requirements, complicates the problems of antenna selection and location. This document presents the results of an NELC study to provide two hf antennas (1) with maximum possible isolation between them, (2) with reasonable antenna system efficiency, and (3) so arranged that they meet the HERO requirement for the PHM weapons.

NELC recommends that a fan antenna be installed for one hf transceive circuit and a 5.33-meter whip for the other. A second whip is recommended for backup.

Impedance, pattern, and isolation data are presented.

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Patrol Hydrofoil, Missile (PHM)						
Hf communications – Antennas						
Near-field levels						

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